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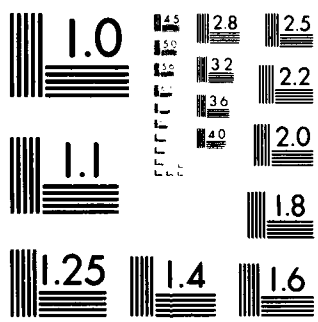

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The overall objectives of this report are to assess the impacts, both positive and negative, of the Corps of Engineers' activities on Pool 8 (confluence of Root River, LaCrosse River with the Mississippi River) on the Upper Mississippi River. The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology and water quality. Socioeconomic systems include industrial and recreational activities, and cultural considerations, which include archaeological and historical sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 8

of the Northern Section of the
UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement ... on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U.S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U.S. Army Corps of Engineers contracted with the North Star Research and Development Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the Mississippi River from the head of navigation in the Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from their respective heads of navigation at Shakopee and Stillwater, Minnesota to the Mississippi River. This portion of the Mississippi River basin will subsequently be termed the "Northern Section" of the upper Mississippi River, the "study area", or the St. Paul District.

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river

to permit navigation as far as Fort Snelling. Later in the 1870's, further improvements were made, primarily through construction fo wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools, which were created by the construction of navigation locks and dams in the 1930's. Several recreation areas along the river were also built by the Corps.

The purpose of the enivronmental impact study is to assess the impacts, both positive and negative, of the Corps' activities on the Northern Section. These activities are defined as operations and maintenance activities and mainly include operations of facilities (lock and dams) and maintenance of the navigation channel (dredging). Actually, the impacts on the environment of the earliest operations are also being sought, but most of the information will concern those of the present navigation system.

The studies are designed not only to identify the impacts, but to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it may be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental

impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U. S. Army Corps of Engineers.

Scope of Current Report

The present report covers the entire study program only from January, 1973 through November, 1973. The report contains both historical information and data collected in the field from activities such as water sampling and wildlife observation.

Research Approach

Three aspects of the research approach used in the study are: (1) the benchmark point in time, (2) data collection and analysis on the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it is necessary to select a time period that can serve as a benchmark. This benchmark represents the state of the Mississippi River prior to the time activities related to the nine-foot channel were initiated. As the nine-foot channel project was constructed in the 1930's, the preconstruction benchmark was taken as 1930. Wing-dams were built and other Corps' activities took place prior to 1930, however, and earlier data were also used where they were readily available. The preconstruction benchmark data were obtained from available reports and from a variety of other sources cited at the end of each section.

Analysis of the Natural Systems

The impacts of Corps' activity on the natural environment for a given pool were determined by the individual investigator responsible for that particular pool. The Northern Section of the upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower Saint Anthony Falls (SAF) Pools (a single report covers both pools), the Minnesota River, and the St Croix River. A segment was assigned to an investigator on the natural sciences team as listed below:

Number of River Segments Involved	Total Length in River Miles	River Segment	Responsibility	Organization
5	92.4	Upper and Lower Pools, Pool 1, Pool 2, Minnesota River and St. Croix River	Roscoe Colingsworth	North Star Research and Development Institute, Minneapolis, Minnesota
1	18.3	Pool 3	Edward Miller	St. Mary's College, Winona, Minnesota
4	82.6	Pools 4, 5, 5A & 6	Calvin Fremling	Winona State College, Winona, Minnesota
2	35.1	Pools 7 & 8	Thomas Claflin	River Studies Research Group University of Wisconsin, La Crosse, Wisconsin
1	31.3	Pool 9	James Eckblad	Luther College, Decorah, Iowa

Number of River Segments Involved	Total Length of River Miles	River Segment	Responsibility	Organization
1	32.8	Pool 10	Edward Cawley	Loras College, Dubuque, Iowa

Because different problems arise in different segments of the river, each investigating team used its own judgement in conducting its studies. However, North Star--in conjunction with the investigators cited above--developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a reporting format that could be used for all pool reports so that the series of reports would have maximum utility and comparability.

Analysis of Socioeconomic Activities

The socioeconomic analysis for all pools in the study area was conducted by a team including Dr. C.W. Rudelius of the University of Minnesota and William L.K. Schwarz of North Star. The socioeconomic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socioeconomic portions of each pool report.

Report Objectives

Since the Corps is required to submit an environmental impact statement for each pool and tributary in the Northern Section on which they carry out operation and maintenance activities, this study is being carried out and reported on by pool (and tributary).

The present report deals only with Pool 8 on the upper Mississippi River described in detail in subsequent pages. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to Pool 8. Specifically, following this section, the report is in the format required for the Environmental Impact Statement, and seeks:

1. To identify the environmental, social, and economic impacts of the Corps activities related to Pool 8.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps' activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers and other public agencies and private groups to reduce

detrimental aspects of the project.

4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water. Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams and commercial fishing; recreational activities, such as fishing, boating, or hunting that are affected by Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

Lock and Dam No. 8 is located 679.2 river miles above the mouth of the Ohio River and is the 11th of 13 like structures down-in the canalized section of the Mississippi River in the St. Paul District. The structure is 23.3 miles below lock and dam No. 7 and 31.3 miles above lock and dam No. 9. The main lock system is located on the Wisconsin side of the main channel of the Mississippi River (Figures 1-5).

A movable dam section consisting of 5 roller gates and 10 tainter gates extends from the auxiliary lock to the right bank of the main channel. An earth dike connects to the end of the movable dam and angles for a total distance of 15,720 feet across bottom land area and ties into higher ground on the Minnesota side of the valley. The dam circumvents Reno Bottoms at its upstream perimeter. This latter area is subsequently contained in Pool No. 10. Submersible dam sections of 938 feet and 1337 feet respectively are located in two sections of the earthen dam. The combined structures are designed for a lift of 11 feet in pool elevation which provides for a 9-foot channel upstream to Lock and Dam No. 7.

Pool 8 is the third longest of the 13 project pools in the St. Paul District and in the lower reach above Lock and Dam No. 8 has one of the broader expanses of water surface relatively unbroken by interspersed islands.

Goose Island, located in the pool just downstream from LaCrosse,

Wisconsin, is one of the largest Corps administered land areas in the district that is completely surrounded by pool water.

Two tributary rivers enter the Mississippi River in Pool 8. The Root River enters from the Minnesota side and the LaCrosse River enters from the Wisconsin side. The original confluence of the Black River was located in what is now Pool No. 8; however, it now enters and mixes with the water of Navigation Pool No. 7.

The principal features of the pool are summarized below:

A.	Length of pool	23.3 river miles
B.	River Miles	679.2 to 702.5
C.	Pool elevation (flat pool)	631.0
D.	Area of pool (water)	20810
E.	Shoreline (perimeter)	85 miles
F.	Land above flat pool	10282 acres

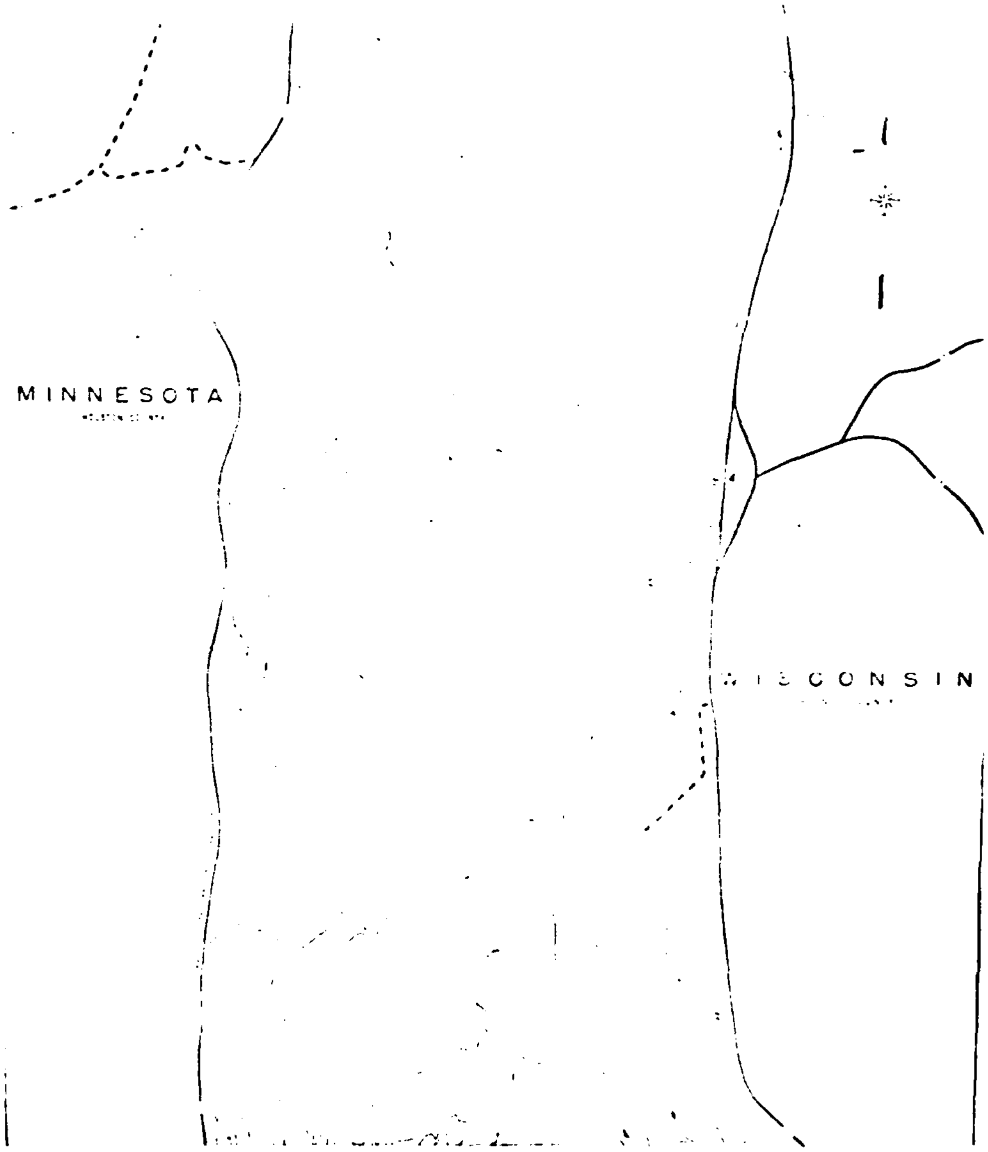


Figure 1. Navigation Pool No. 8, Mile 676-682

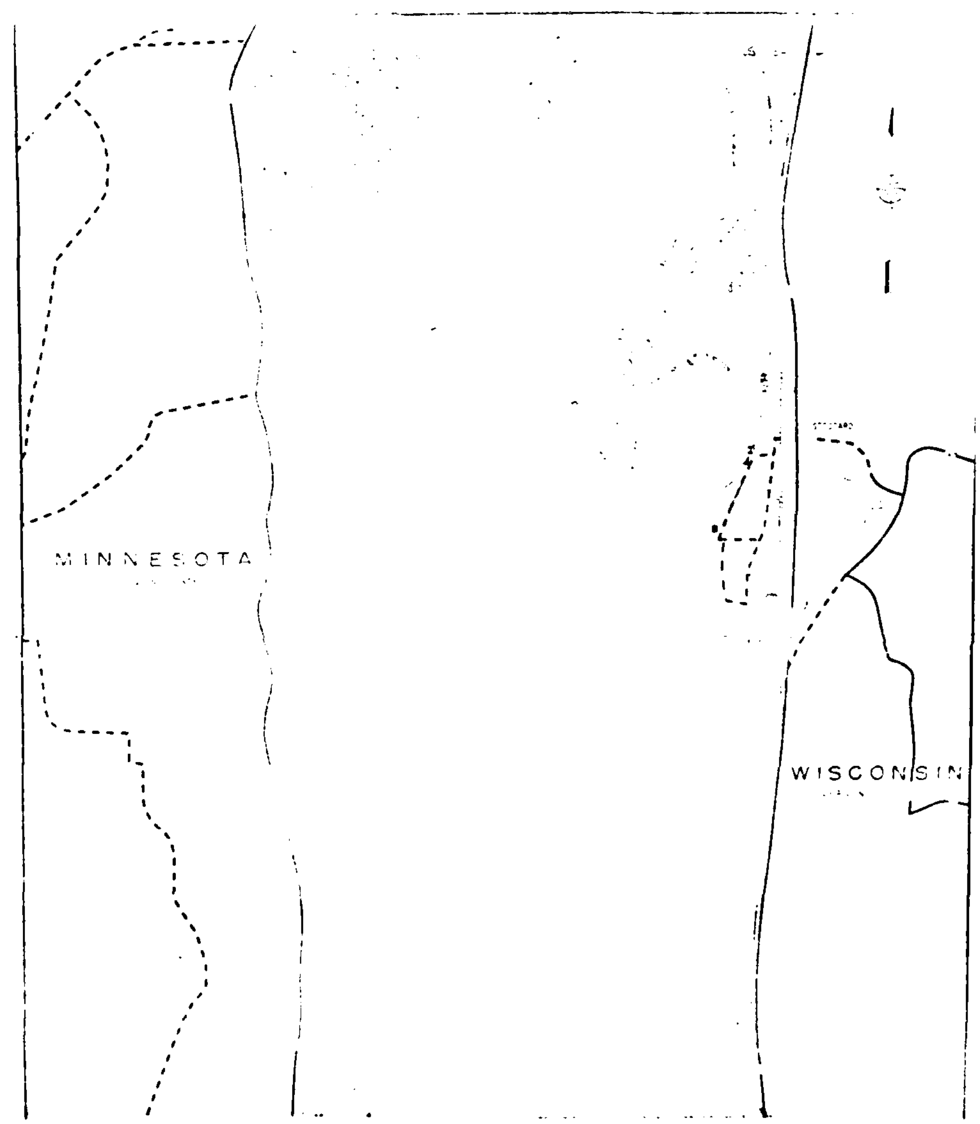


Figure 2. Navigation Pool No. 8, Mile 682-688

Figure 3. Navigation Pool No. 8, Mile 688-694

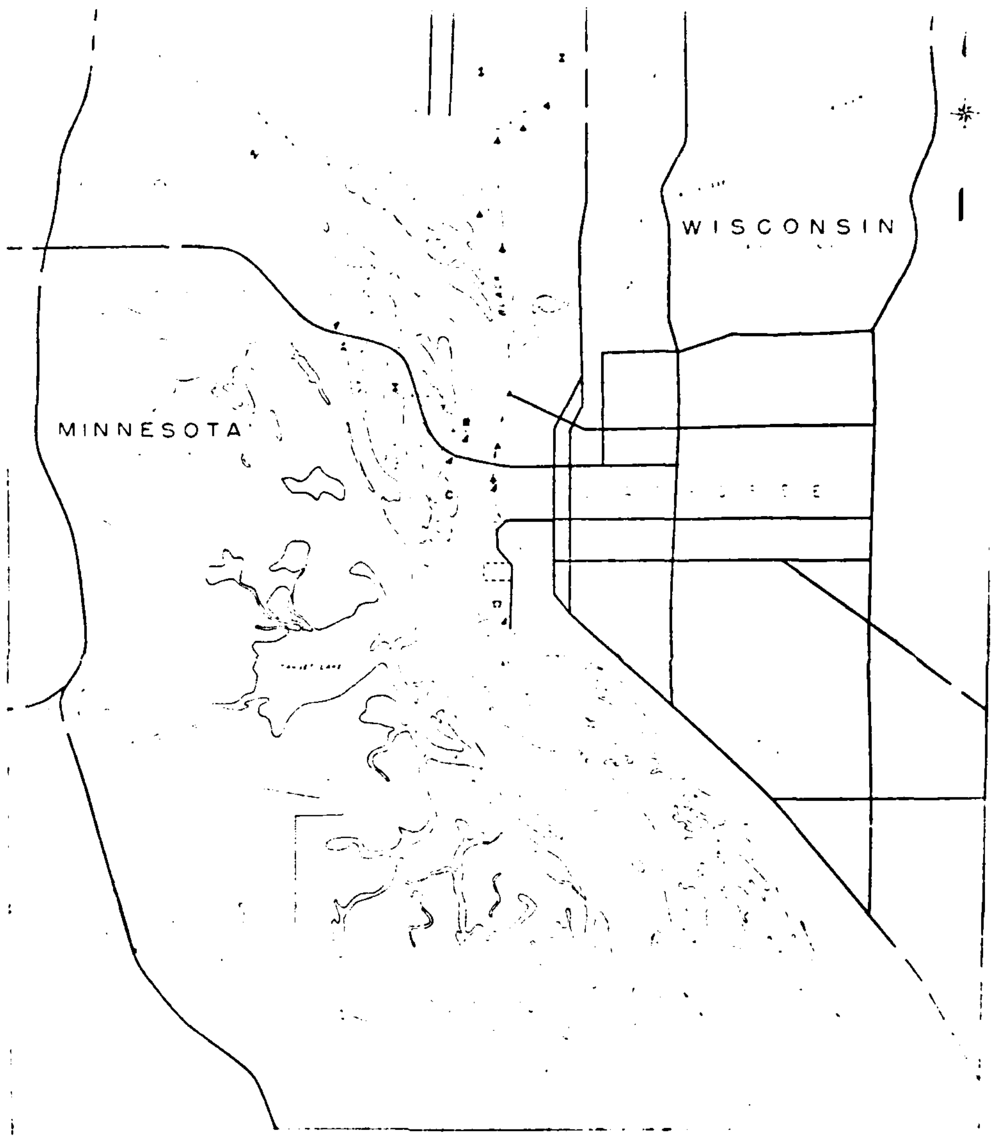


Figure 4. Navigation Pool No. 8, Mile 694-700

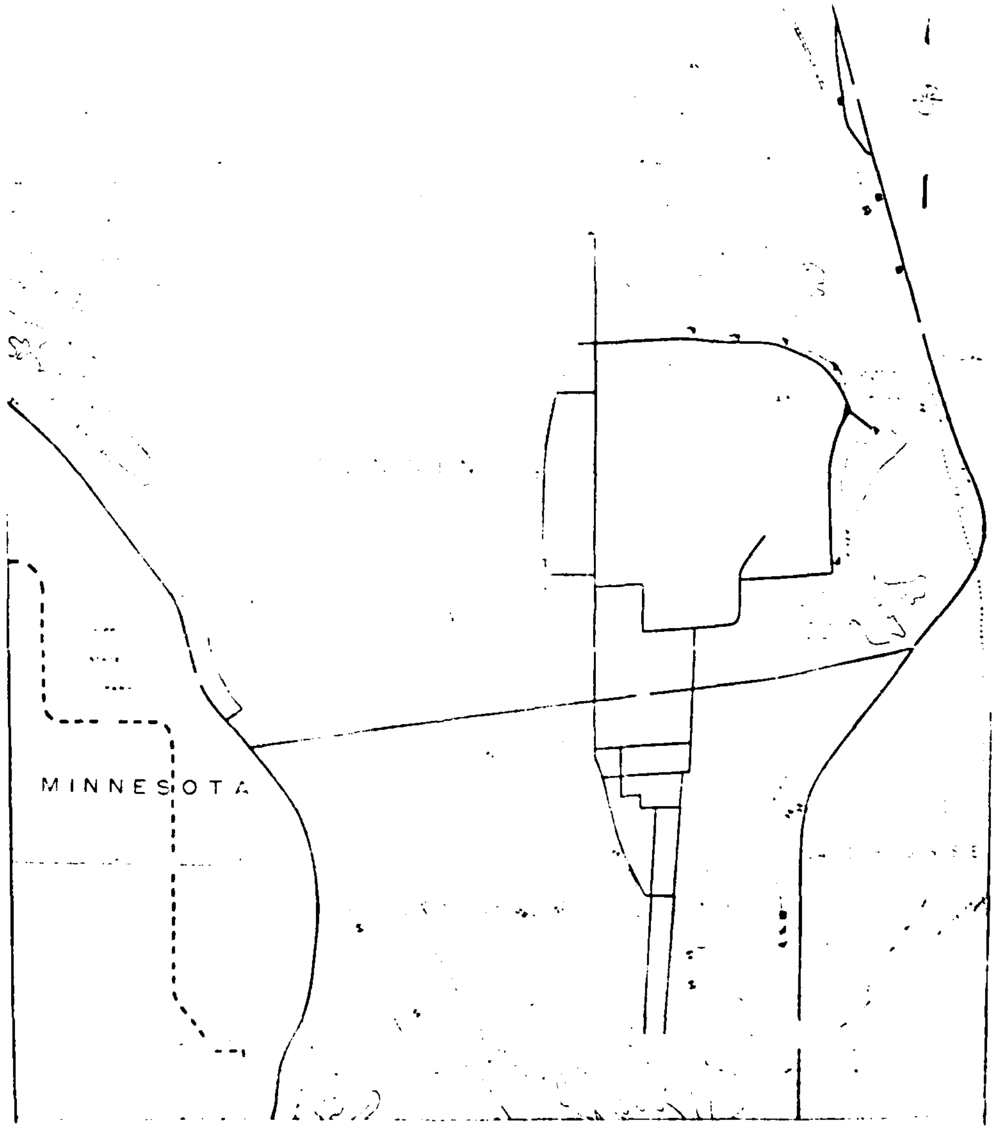


Figure 5. Navigation Pool No. 8, Mile 700-704

2. ENVIRONMENTAL SETTING

INTRODUCTION

The environmental setting of the project covered in this section is divided into (1) the natural setting and (2) the socioeconomic setting and includes a description of the study area from prior to the authorization of the nine-foot channel (1930) up to the present time. Lock and dam No. 8 was opened to navigation in 1937. Thus because the project under consideration was initiated approximately 40 years ago, it is difficult to reconstruct accurately, the natural and socioeconomic setting existant prior to the construction phase. There are these three reasons for this difficulty:

1). lack of precise data on the environmental setting prior to 1930.

2). the difficulty in isolating some changes in the river environment due to the nine-foot channel from those caused by the earlier 4 1/2 and 6 foot channels or by increased population and industrialization along the river; and

3). the practical emphasis on reducing the environmental impact of operating and maintaining the nine-foot channel assuming its continuation--not eliminating it entirely.

Therefore, the descriptions of the pre-project environmental settings, particularly the socioeconomic, in this section were constructed from available published information and are of necessity brief and not complete.

In the discussion of the environmental impact of the project later in Section 3, an attempt has been made to identify changes in the study area occurring in the past four decades that are attributable to the nine-foot channel project.

History of the River Basin

The exact age of the Mississippi River is not known. The existing gorge was probably cut prior to the Wisconsin stage of the glacial period. In fact it appears that the gorge may be preglacial. The gorge was partially filled with glacial outwash during the drift period. Terrace formation occurred, depositing the first terrace at a height of over 100 feet above the present floodplain. Following the filling of the river gorge, a period of terrace cutting occurred, leaving remnants of terraces along the lower borders of the bluffs. Many of these terraces have since been cut by tributary streams. This change from deposition to erosion is related to the large volume of water from the southward flow from Lake Agassiz. The water being derived from an extremely large lake carried little or no sediment for deposition in the river basin. The third stage in the development of the Mississippi River was a period of floodplain deposition. With the pronounced decrease in flow due to the lack of glacial melt water, the river became dependent upon rainfall and runoff from its own basin. Since it could not carry the sediment load delivered by its tributaries and the head water, deposition resumed and is occurring at the present time.

The sand processes probably occurred in the tributary streams, particularly those that enter the Mississippi River in the driftless area.

Navigation Pool No. 8 now occupies an area that was once low lying marsh, meadow, and low wetland forest. The channel of the Mississippi River meandered through the wide floodplain, and formed a large number of oxbow channels and sloughs on the floodplain.

The Floodplain

Where the Mississippi River is contained within a gorge as in the area of Pool No. 8, the floor of the gorge shows two conspicuous features: A. the floodplain of the river, which occupies most of the bottomland, and B. the terraces, which are narrow and discontinuous. The floodplain slopes southward from an elevation of 675 feet at Prescott, Wisconsin, to 592 feet at Dubuque, Iowa. The distance between these points being 260 river miles, the grade of the river is slightly less than four inches per mile. The floodplain material is clay, silt and loam, sometimes sandy, and often dark with organic matter. This topsoil is underlain by several feet of sand, which often grades into coarse gravel from 3 to 6 feet below the surface. The basin abounds with pools and small lakes where decaying vegetation constitutes the floodplain material. This surface material, however, is extremely thin compared with the great thickness of glacial outwash below.

Climate

The climate in the area of Pool No. 8 is a humid-continental

of the LaCrosse River lies within the terrace near the base of the Wisconsin bluff. The northern end of this terrace is cut into several parts between the LaCrosse River, the Black River, and the French Slough on the Mississippi River. Whereas there is only one terrace preserved at LaCrosse, one of the lower of the Mississippi River Series, there are three or four located north of Onalaska. The levels represented are 1). the 20-35 foot terrace of Brices Prairie, French Island, North LaCrosse, and Onalaska 2). the 50 foot terrace east of North LaCrosse, and 3). the 80 foot terrace upon which rests Onalaska. Irregularities can be seen on this terrace due to sand dune formation.

These terrace provide a suitable place for people to settle and populate. However, outwash from these terraces tends to create uniformity in the floodplain by filling small channels. Since terraces are formed from relatively unstable materials, this tendency can be observed within the floodplain of the Mississippi River. Thus an elevation in water level of only a few feet has resulted in the inundation of thousands of acres of lowland.

Soils

The soils in the area of Pool No. 8 have been derived from a variety of parent materials. In a few places, particularly on the steep slopes in the Driftless areas, on the escarpments overlooking the Mississippi River, the soils are derived directly from weathering of the bedrock materials. In the majority of the watershed, however, the soils are derived from the covering materials. This is most

commonly glacial till, but in some areas, alluvium and loess predominate. The weathering of this till, however, has taken place under a vegetative covering of one kind or another, and has resulted in the predominance of the following soil types: Gray-Brown Podzolic soils, Brunizems, Bog soils, Alluvial Soils and Regosols. The podzolic soils consist of loess or alluvial silts, sand, weathered products of sandstone, or red clay. These soils have formed under deciduous trees in a temperate continental climate. The Brunizems have formed in a temperate humid-continental climate under a cover of tall grasses. The Bog soils have formed in areas where muck and peat predominate, on the lower edges of the terraces in the river basins. Alluvial soils are forming from material recently deposited on floodplains. The Regosols are made up of deep soft mineral deposits in which few or no clearly expressed soil characteristics have developed.

The loess cap which covers the southern one-half of the state of Wisconsin, lies as a blanket over the other parent soil types and can be found as deep as 16 feet in some areas of the Mississippi River floodplain. Composed of silt size particles, it is uniform in distribution and chemical composition. Whereas one might expect to find different vegetational patterns in the driftless area because of the exposure and weathering of ancient rocks, as opposed to glacial till, the loess cap provides a constant substrate of recent origin for vegetation to develop on, thus obscuring any effect of the original rock type.

WATER QUALITY

Natural

The term water quality will be used to describe the natural, unaltered characteritics of the water received by Navigation Pool No. 8 from the Mississippi, LaCrosse, and Root Rivers.
Since most of the geological features in the uppermost portion of the watershed are old Cambrial formations, the water in this part of the river is quite soft. Total hardness rarely exceeds 175 mg./L in Navigation Pool No. 8 and does only where emergent ground water of local origin is concentrated in the pool. The alkalinity of the water varies lightly around 175 meg./L and the water has a characteristic brown color from the dissolved organic substances leached from forest floor areas. Aeration processes maintain the dissolved oxygen in excess of 60% during all parts of the year. Whereas the water is not well buffered, the pH remains slightly alkaline during most of the year. The water received from the Root River is similar in natural quality as the Mississippi River water. However, the Root River, because of the topography of its watershed, is subject to rapid changes in discharge. When discharge is above normal, this river carries extremely high silt and clay loads. Data collected during the spring of 1973 indicate that the turbidity of the Root River was in excess of ten times that in the Mississippi River.

The LaCrosse River has its confluence with the Mississippi River within the city limits of LaCrosse, Wisconsin. It has a relatively

small but heavily populated watershed. Because the LaCrosse River has three artificial impoundments in its upstream reaches, during normal water discharge periods, the turbidity of its water is relatively low. During flood periods, however, because of the heavy land use in the watershed, the LaCrosse River discharges large quantities of silt and clay into the Mississippi River.

Altered Water Quality

The water entering the upstream end of Navigation Pool No. 8 received approximately 15 million gallons per day of sewage effluent from the LaCrosse Municipal waste treatment plant. Until 1972, the city of LaCrosse operated a primary settling waste treatment facility with a relatively low efficiency. However, a newly constructed activated sludge system is now on line, but now effluents approximately the same volume of adequately treated sewage. The material is discharged directly into the main channel at river mile 694, and it diffuses directly into the main body of Navigation Pool No. 8. Additional effluents enter Navigation Pool No. 8 from diffused sources such as seepage from septic systems located along the shoreline.

Ground Water

The groundwater table in the floodplain of the Mississippi River ranges from 10 to 30 feet, depending upon topography. This highly productive aquifer is open to and in direct connection with the Mississippi River. Groundwater from a maximum depth of approximately 100 feet is typically naturally filtered river water and is

of excellent quality. The water from depths below 100 feet is typically native groundwater from the LaCrosse area, is harder, and has an iron content of 0.1 - 1.0 mg./L. This water comes from Cambrian sand stone formations, and it appears that there are many layered aquifers in this formation.

VEGETATION

Terrestrial Vegetation

The vegetation in the watershed adjacent to Navigation Pool No. 8 can be divided into two general groups; the upland xeric southern forests of Wisconsin and Minnesota, and the southern lowland vegetation of the floodplain.

The upland xeric forests are predominately oak forests. They are located on well drained sites on either sandy and porous flatlands, on south and west slopes of hills, or on thin soils on hilltops and ridges. In a study of 127 forests located south and somewhat west of the tension zone in Wisconsin (the southern 1/3 of Wisconsin including 80% of the Mississippi River bordering Wisconsin), 29 species of trees were found (Table A1). An analysis of the groundlayer species indicate that more than one-half of the species are included in nine families. The Compositae comprise 10% of the total species in the dry mesic stands and ferns are dominant. Other families in the group of nine are the Framineae, Ranunculaceae, Rosaceae, Umbelliferae, and Caprifoliaceae (Table A2).

The valley forests are commonly known as bottomland or floodplain

forests and the lake border types are usually termed hardwood swamps. They are similar because the soil moisture supply is in excess of that falling as rain. The floodplain forests are present along all the rivers tributary to the Mississippi and on the Mississippi floodplain. The composition of the forest differs greatly from the upland forests and groundlayers (Table A3). Of the 37 species listed, 21 were found in the initial or wet segment and 36 in the intermediate wet mesic segment. The lowland forests thus have more species of trees than any other community in the area. In large part, this is due to a number of species of southern derivation which have progressed northward in river valleys. These include the buckeye (Aesculus glabra), the honey locust (Gleditsia triacanthos), the sycamore (Platanus occidentalis) and the river birch (Betula nigra). *The average values tend to obscure* the fact that several different combinations of species are included within the wet segment. In the pioneer sites along sand bars, mud flats, and other places of recent soil disturbance, the usual forest is dominated by black willow (Salix nigra) and cottonwood (Populus deltoides). On open sites near the upland edges of the wet ground, river birch or swamp oak (Quercus bicolor) are the usual dominants. As both of these types mature, they are invaded by silver maple (Acer saccharinum) and American elm (Ulmus americana). The moist forest, particularly the riverine stands, tend to have a high total basal area per acre, with an average of 14,300 sq. in. per acre. This is cue to the large size of the trees rather than high densities. This can be substantiated by examining the size of the stumps remaining from

the timber clearing activities in the navigation pool areas prior to inundation.

The prevalent groundlayer species of the lowland forest are reported in Table A 4 . The floristic homogeneities as shown by the ratio of prevalent species sum of presence to total species sum of presence are low (Curtis, 1971) Analyses of the total flora reveal that the same seven families include 50% of the total species. The main change in family representation as compared to the upland forest, is the prominent role of the sedge and mint families and the increased importance of the carrot and nettle families. The low values of average presence for the prevalent species of the set stands are an indication of the great variation to be found from stand to stand. This is due to the frequency of flooding.

Succession

The pioneer stages of the lowland forests occur on two different sites. Toward the river's edge on wet newly deposited banks, conditions are favorable for the establishment of cottonwood and willows. As these mature, they tend to be replaced by the silver maple and American elm in the absence of further disturbance by the river. Toward the upper side of the floodplain, soil conditions are more stable and favor the invasion by the river birch or the swamp white oak.

Aquatic Vegetation

The composition of the aquatic vegetation communities prior to navigation lock and dam formation is virtually unrecorded. However, based on

species, the white tailed deer is the most popular big game animal. Small game mammals that are hunted, include the gray squirrel and the cottontail rabbit. The majority of the hunting however, is for migratory waterfowl. The Mississippi flyway provides a suitable habitat for in-route migratory rest areas, and in locally nesting species, marshalling areas during pre-migratory periods. Not only does the area of Navigation Pool No. 8 provide these areas for north-south migratory corridors for mallards, pintail, gadwall and teal, but it is situated such that it lies in the east-west corridors utilized by canvasbacks and redheads. Whereas the principal goose migratory corridors lie east and west of the upper Mississippi River basin, there is quite an extensive use of this area in southwestern Wisconsin, particularly by snow geese.

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and (2) by presenting an overview of these activities in Pool 8 as they also relate to the northern section of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconimic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on forms, in barge operations, commercial dock facilities, lock and dam operations, and commercial fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of avaliable data makes this impossible in the present study. As a result, indices of this industrial activity -- such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught -- are used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of being near or on the Mississippi River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the Mississippi River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available -- such as fishermen using a specific pool -- proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools -- even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural considerations are the third component of the socio-economic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and contemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of

ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of Pool 8 are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and the South.

Historical Development of the Waterway

The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competetive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order

to simplify both engineering design and fuel energy demands. Thus, the Mississippi River valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctiations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823 and steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U. S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving

logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920s large grain shipments from Minneapolis began.

Although 4½ and 6 foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U. S. , technological developments in barges and tugs led to the authorization of a nine-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical

collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930s due to the construction of locks and dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930s) does not necessarily reflect a normal period of transportation on the upper Mississippi River.

Barge Shipments. Table shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 1. River shipment from 1920 through 1945.

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mlps. to Mouth of Missouri Riv.
1925	908,005	Mlps. to Mouth of Missouri Riv.
1926	691,637	Mlps. to Mouth of Missouri Riv.
1927	715,110	Mlps. to Mouth of Missouri Riv.
1928	21,632	Mlps. to Mouth of Wisconsin Riv.
1929	1,390,262	Mlps. to Mouth of Ohio River
1930	1,395,855	Mlps. to Mouth of Ohio River
1935	188,613	Mlps. to Mouth of Ohio River
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes transit.

Source: Annual Report of the Chief of Engineers, U. S. Army, Part 2 "Commercial Statistics", Table 7, by sleected year.

In more recent years, data are available for the St. Paul District. Table 2 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

Sources:

*Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U. S. Army Engineer District, St. Paul Minnesota

** Estimated

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due in a large degree to grain shipments from the district and to an increase in receipts of coal.

In 1928, data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,000 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the none-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972, this had doubled to 16,000,000 tons.

Pool No. 8 contains seven commercial docks and terminals -- including two that supply petroleum products to Socony Mobil Company and Texaco, and one that transships grain for the Cargill Company. In addition Pool 8 serves as a thoroughfare for the river traffic shown in Table 3 that moves between the region south of Pool 8 and the

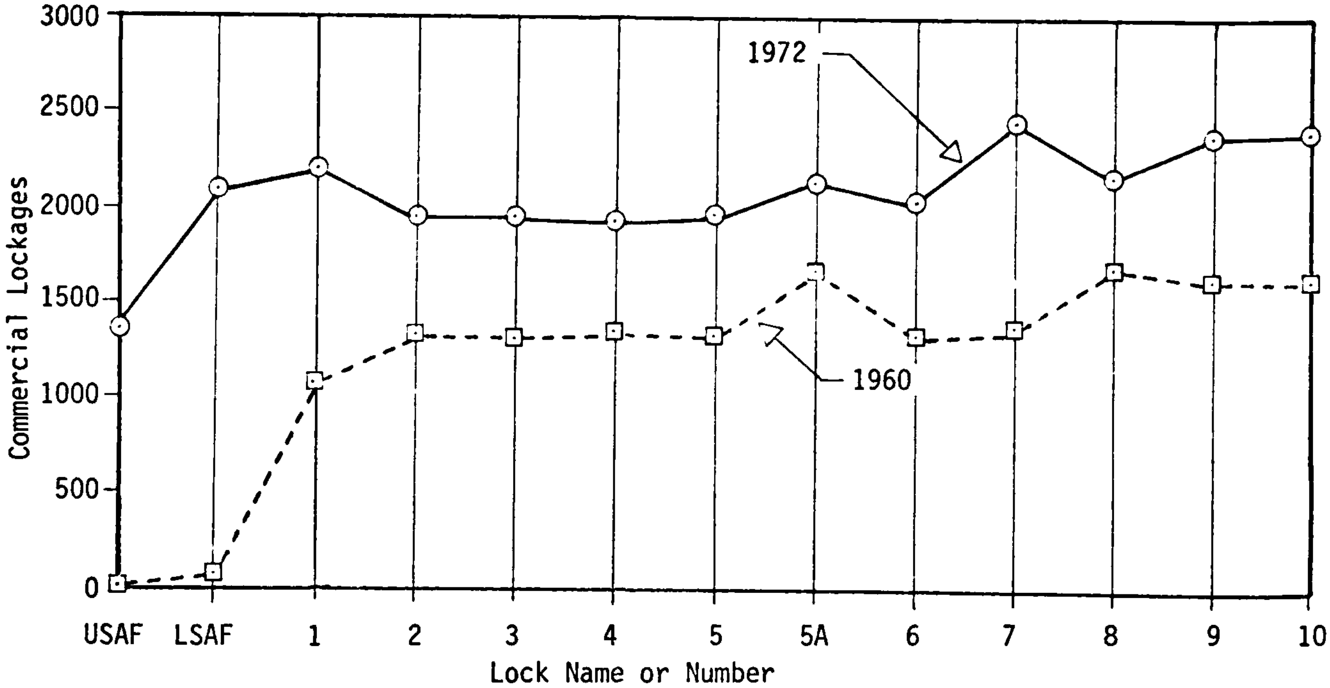
Twin Cities. An indication of the "thoroughfare" function that Pool 9 provides for barge traffic in the study are the commerical lockages through all locks in the Northern Section that are shown in Figure No. 6. These also provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the river between Lock and Dam 2 and Lock and Dam 10 increased by about 600, the approximate increase that was also present for Lock and Dam 8.

Table 3 shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

Transportation Mode	Upbound	Downbound
Self Propelled		
Passenger & Dry Cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-self Propelled (Barge)		
Dry Cargo	25,250	25,237
Tanker	7,312	7,311
TOTAL	42,898	42,844

Source: Waterborne Commerce of the United States Calendar Year 1971 Part 2; Department of the Army U. S. Army Corps of Engineers p. 165.

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to



Source: St. Paul District of the U.S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972.

Figure 6. Commercial Lockages in Upper Mississippi River in 1960 and 1972.

mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System ranged from 700 to 800 miles. This indicates that the great bulk of shipments and receipts have origins or destinations outside of the St. Paul District. Each pool then, in addition to its own shipments and receipts contributes to the economic benefits enjoyed by the system as a whole. Thus, any measure

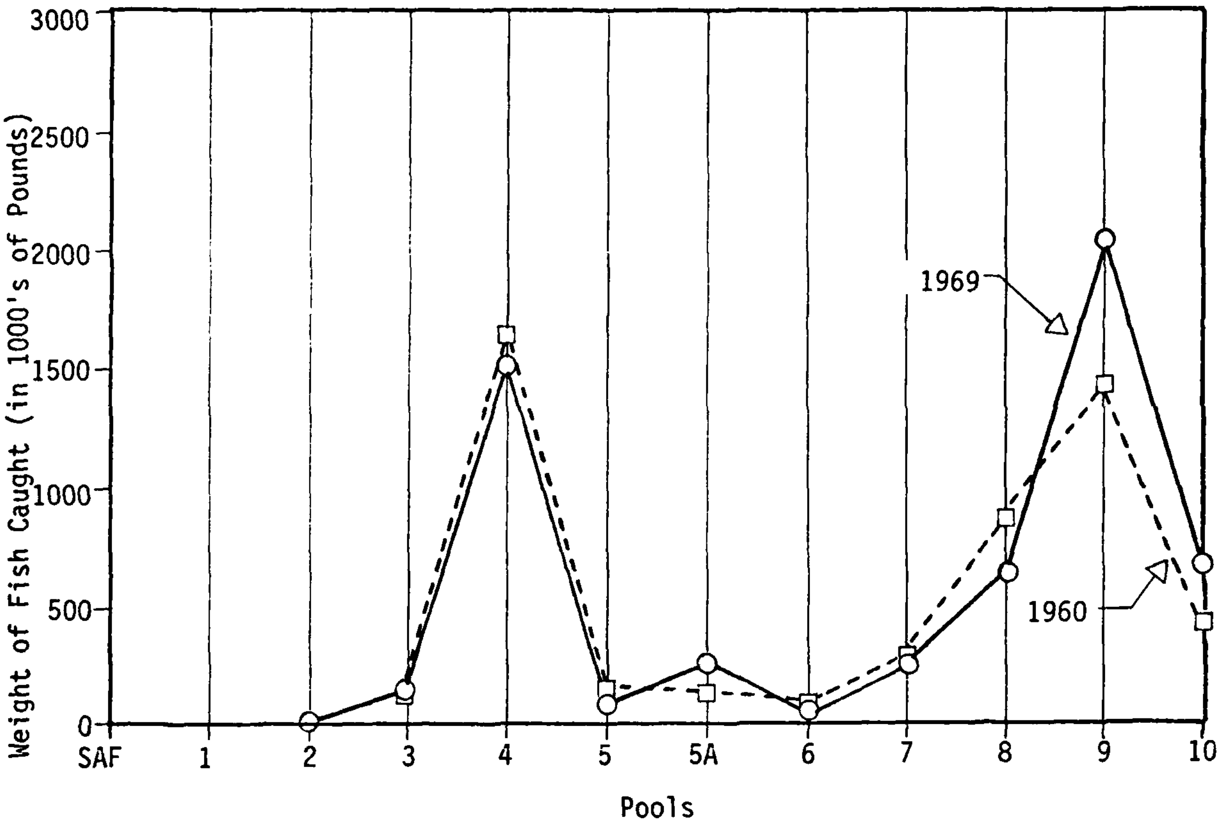
of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the Upper Mississippi system.

Commercial Fishing and Trapping. As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing and trapping along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

Limited data are available on the extent of commercial fishing and trapping prior to 1930. However, the rise in the water level behind the newly constructed locks and dams in the Upper Mississippi River after 1930 increased marsh development and provided more fish and fur animal habitat over that existing prior to the construction.

Data on commercial fishing in the 1960s in the pools in the study area are shown in Figure 7. In 1969 the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially; this was an increase of about 9 percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000. Figure 7 shows that the bulk of the commercial fishing in the pools in the study area -- about 4.8 million pounds of fish and 86% of the total -- occurred in Pools 4,8,9, and 10. Pool 9 is the major contributor, with 2 million pounds in 1969. Pool 8 contributed 622,000 pounds during that year.

Trapping data have been collected for the past three decades by the Upper Mississippi River Wildlife and Fish Refuge, which is managed



Source: UMRCC. Proceedings of Annual Meeting, 1962 and 1971.

Figure 7. Thousands of Pounds of Fish Caught Annually by Commercial Fishermen in Upper Mississippi River Pools in 1960 and 1969.

by the Bureau of Sport Fisheries and Wildlife of the U. S. Department of the Interior. This refuge was established by Congress in 1924 and runs for 284 miles along the Upper Mississippi River from about Wabasha, Minnesota to above Rock Island, Illinois -- or from approximately Lock and Dam 4 to Lock and Dam 13. Between 1940 and 1970 an average of 748 trappers per year obtained trapping permits. Between 1940 and 1970 25,000 beavers and over 2.25 million muskrats were trapped whose furs averaged nearly $100,000 annually (Green, 1970).

By the 1971-72 season, the price of muskrat pelts was over $1.00 and the annual harvest was valued at about $200.000.

Recreational Activity

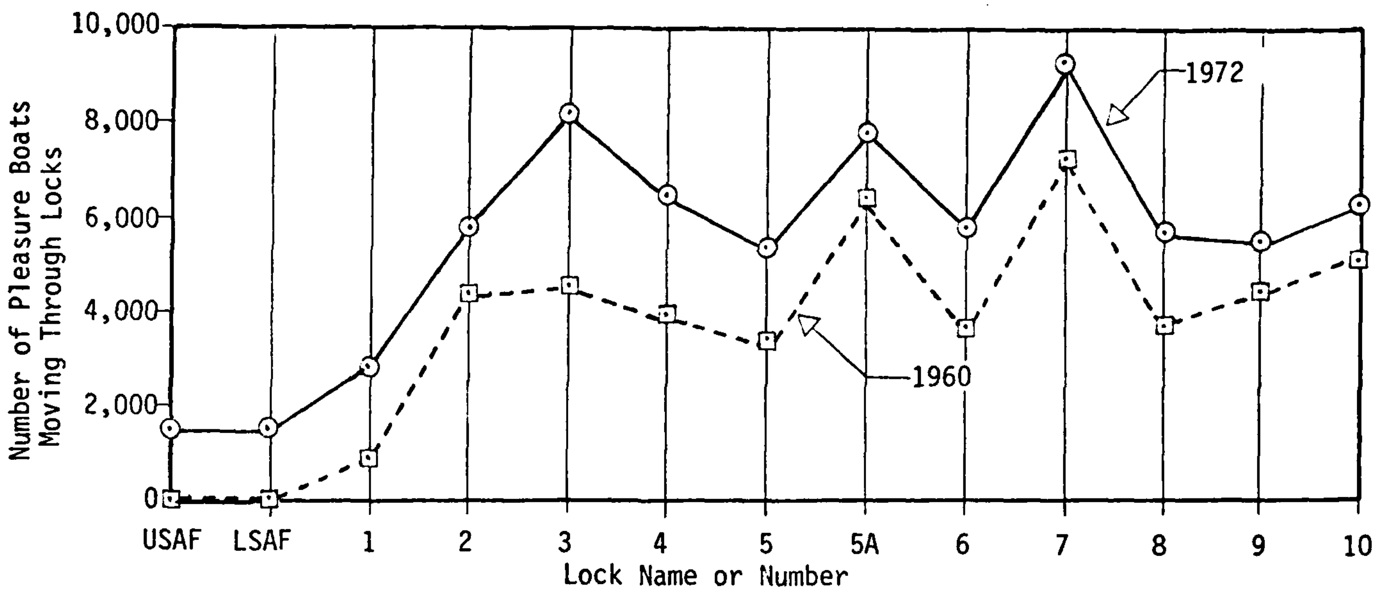
In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4½ foor channel in 1878 -- the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul -- settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wildnerness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating then was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish and game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, leisure time accompanying the settler's higher standard of living led to recreational uses of the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930 prior to the nine-foot channel, presents problems. These arise because

of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river -- and virtually all of it for the deeper draft pleasure boats -- is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 8 illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. The figure shows that numbers of pleasure boats moving through each lock in the study area increased by an average of about 1,500 boats during the twelve year period. It can be seen that the number of pleasure boats moving through Locks 7 and 8, those at each end of Pool 8 increased by about the average for the District during this period. In 1968, the Corps of Engineers inventoried 17 major public use facilities on the river in Pool 8 that mainly serve



Source: St Paul District of the U. S. Army Corps of Engineers, Annual Lockage Data, 1960 and 1972.

Figure 8. Pleasure Boats Moving Through Upper Mississippi River Locks in 1960 and 1972.

pleasure boaters through providing water access for on-water types of activities. These 17 facilities are managed by a variety of federal, community, and private groups, such as the U. S. Bureau of Sport Fisheries and Wildlife, and the communities of Stoddard and LaCrosse.

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using each specific pool in the study area are not available. Although sport fishing survey data are available for Pools 4,5, and 7 in the study area, comparable data do not exist for the other pools. Perhaps the only comparable data for all pools are the number of sport fishermen observed annually by attendants at lock and dam sites. Attendants to each lock and dam observe the river pool areas above

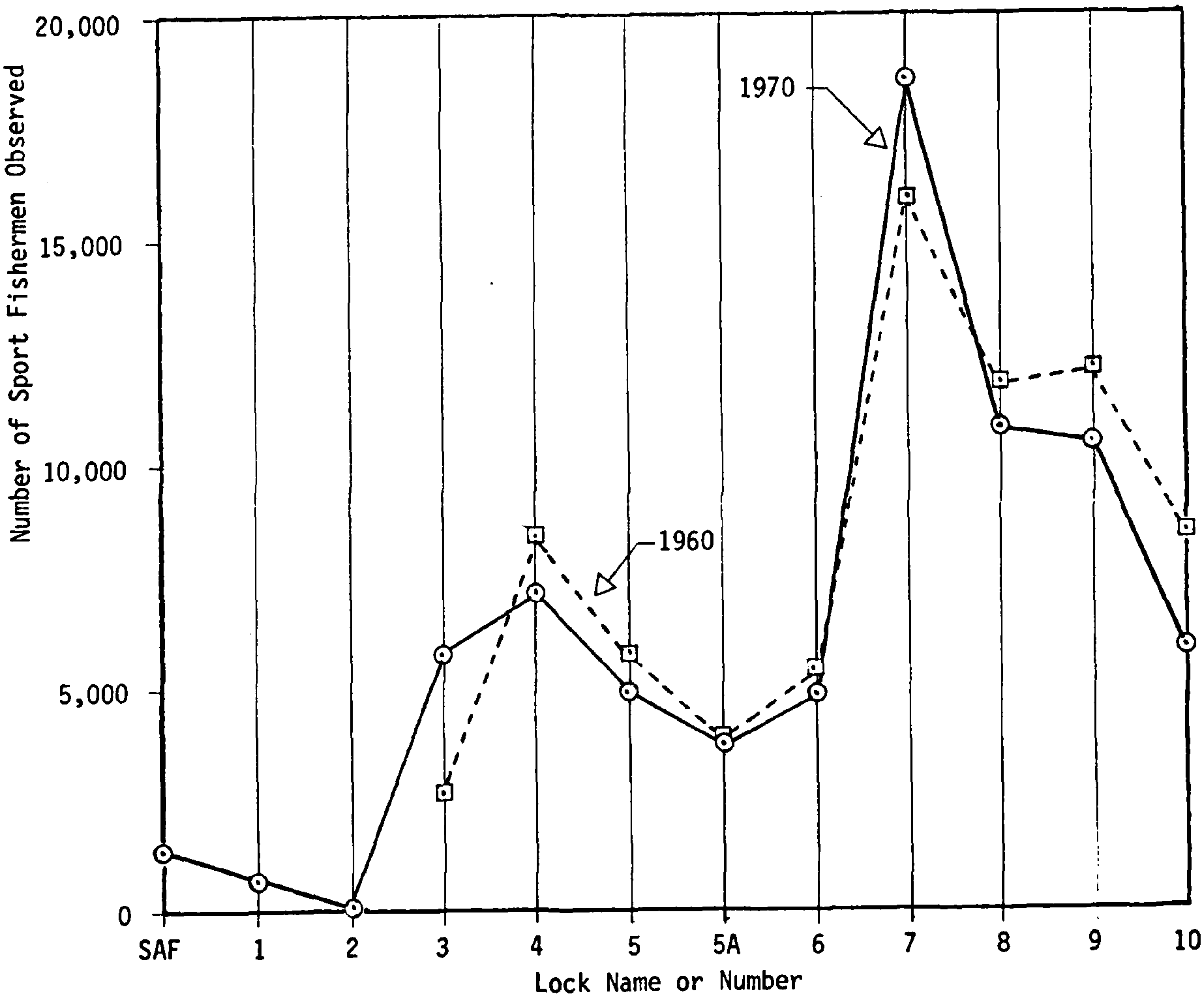
and below their site at 3:00 p.m. each day and record the number of sport fishermen seen; the annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 9 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high concentration of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in this figure are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in 1970 over 18,000 fishermen were observed from Lock and Dam 7, most of them fishing in Pool No. 8. This is the largest number observed from any lock and dam in the St. Paul District.

Sport hunting of waterfowl along the Mississippi River study area is large. It is estimated that in 1963; the year for which the most precise data are available, hunters made about 15,600 visits to Pool No. 8. The LaCrosse District of the Upper Mississippi River Wildlife and Fish Refuge (which covers both Pools 7 and 8) estimates that for the ten years from 1961 to 1970, an average of 26,800 hunters in the District bagged an average of 49,750 waterfowl annually.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of

the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally



Source: UMRCC, Proceedings of Annual Meeting, 1962 and 1971.

Figure 9. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970

difficult to isolate the effect of Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

SECTION 2 - SOCIOECONOMIC REFERENCES

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3. Environmental Impact of the Project

Introduction

The changes in the river system in Pool No. 8 that have been effected by the Corps of Engineers with the construction of the nine foot channel are as follows:

1. The construction of a dam across the Mississippi River main channel to elevate the pool a total of 11 feet.
2. The construction of a 600 foot lock to accommodate the passage of commercial and recreational craft.
3. The construction of auxiliary structures to protect the shorelines adjacent to the channel for the maintenance of a nine foot channel.
4. Maintenance dredging in the navigation pool to maintain the minimum nine foot channel depth.

Whereas the specific assignment of cause and effect with regard to impacts to the above components of the project is difficult, the rise in water level and maintenance dredging account for the major changes that are occurring in the pool area.

Natural Systems

The closure of Lock and Dam No. 8 resulted in an immediate 11 foot rise in the pool elevation upstream from the dam. This rise in water resulted in large scale changes in the habitats within the affected area. A tabulation of areas lost and gained are shown in Table 4 . These figures are derived from a planimetric comparison of

the 1970 navigation charts and the 1930 flowage survey charts. The terminology on the two sets of charts varied slightly, and resulted in slight problems in resolving the comparability of the habitats. Consequently a few of the categories were combined where doubt existed as to their nature. An attempt was made, however, to measure the same areas.

The rise in pool elevation reduced the surface area of the main channel from 5100 acres to 3266 acres, a loss of 36%. Simultaneously 11126 acres of open pool were created. The acreage of open pool includes the lower portion of the main channel where it cannot be distinguished from open standing water, thus accounting for the loss in acreage of the channel.

The relatively small change in acreage of ponds, marshes, and sloughs is probably accounted for by the fact that most of these areas were originally located in what is now the middle reach of Pool No. 8. The areas inundated in the lower half of the pool were primarily timber and wet lowland meadow areas. Prior to inundation, approximately 23000 acres of timber and open meadow existed in the pool area. After inundation, approximately 10200 acres of land remained above the water surface (at flat pool). It must be noted however, that the majority of the acreage of marshland and sloughs were actually destroyed upon inundation, and similar areas were recreated at other locations in the pool. The general trend in Pool No. 8 has been one of lateral displacement of these areas, away from the channel.

Upon closure of the dam, the original main channel (Raft Channel)

was closed and water was diverted through what is now the main channel on the Wisconsin side of the lower pool. The flow patterns into Navigation Pool No. 8 have been altered considerably since closure of the dam.

A majority of the water entering the upper end of the pool is restricted to the main channel. Small feeder channels empty into the large open water areas on the Minnesota side of the upper pool (Target Lake) (Figure 3), but the construction of roadways and floodplain development in these areas have somewhat restricted this flow.

1930		1970
5100	MAIN CHANNEL	3266
-0-	OPEN POOL	11126
-0-	FEEDER CHANNELS	1163
1119	SLOUGH	
1865	MARSH	3820
560	POND	
23000	TIMBER-MEADOW, LAND ABOVE WATER	10282

Table 4. Acreages of ecotypes prior to and after closure of Dam No. 8 (determined planimetrically from flowage survey charts and navigation charts).

The main feeder channel for the Goose Island area (running Slough) was closed during 1969 and 1970, thus restricting flow into this area. Mormon Slough is now the only large feeder channel for water supply into Goose Island.

In the middle reach of the pool, Crosby Slough acts as the feeder channel, emptying water into the upper part of the open pool area on the Wisconsin side. When water in the main channel reaches Brownsville Minnesota, it spreads across the entire width of the open pool and supplies these shallow areas with adequate amounts of fresh water. Water is finally funneled along the earthen dike and is diverted through the dam.

Biological Factors

The creation of large shallow water areas and the increase of water surface area usually tends to increase the amount of energy flowing through the ecosystem. That is, primary productivity increases and subsequently results in increases in productivity at the higher trophic levels, if all criteria for growth are met. Observations made in Navigation Pool No. 8 indicate that this is true here. Rooted vegetation standing crops, benthic standing crops and probably fish standing crops are higher than they were prior to lock and dam construction. The data collected on the transects in Navigation Pool No. 8 during the summer of 1973 appear to support this.

For additional clarification the statistical manipulations will be explained again in this section. The sampling sites on the transects were subgrouped according to their general ecological

habitat type. Whereas the selection of the stations for subgrouping was somewhat subjective, depth, current velocity, sediment type, and distance from the main channel were used as criteria for classification in all cases.

The means for each parameter within each subgroup on the transects were calculated. Analyses of variance were computed for each parameter within each subgroup. Significance in differences between means were calculated by computing the F-statistic. The 99% and 95% levels of significance were determined from the F-distribution table.

Transect AA (River Mile 702.5)

The stations on Transect AA were subdivided into four groups

1. Stations 1-4 (Channel)
2. Stations 5-6 (Slough)
3. Stations 7-9 (Slough)
4. Stations 10-13 (Black River)

Significant differences in turbidity, conductivity, and dissolved oxygen were noted. The highest turbidities were noted in the Mississippi River channel and in the Black River, as might be expected. The highest conductivity was found in the Black River. Similar data are included in the Pool 7 report. The Black River does have higher conductive water than does the Mississippi River. No empirical significance is placed on the differences in dissolved oxygen at the stations, as diurnal changes probably accounted for such differences (Table A9).

Transect BB (River Mile 690.2)

The stations on this transect were placed in the following subgroups:

1. Stations 1-6 (Main Channel)

2. Stations 7-37 (Running and Stagnant Sloughs)

3. Stations 38-52 (Goose Island - open shallow water areas)

Significant differences between the means of the following parameters were noted among the subgroups: Temperature, turbidity, conductivity, orthophosphate, and dissolved oxygen.

Temperature differences were expected. Diurnal changes no doubt, accounted for the differences noted. No ecological significance is place on these data. However, it must be noted, that the fluctuations that do occur, occur through greater ranges in the shallow water areas. The turbidity was higher in the main channel than in the quiet backwater areas. Differences in conductivity are probably accounted for by the effluent of hard water springs and ground water in the Goose Island area. The dissolved oxygen levels were significantly higher in the channel area, but again, it must be noted that great fluctuations of this gas occur in the backwater areas, where photosynthesis and respiration have a greater impact than does mechanical aeration. Ecologically significant is the elevated phosphorus levels in the back water areas (Table A10). As phosphorus is extremely active and dynamic in the aquatic ecosystem, slight elevations are often significant to the biological systems operating in that area. The higher phosphate levels can be regarded as an indicator of increased biological activity and nutrient accumulation. Nitrogen levels were not significantly higher in the same area, as might be expected. Apparently the state of the sediments has precluded the release of nitrogen into the water at this point in time. No further explanation can be offered at this time.

Transect CC (River Mile 679.3)

This transect was the shortest of all transects sampled. Because of the homogeneity of the ecotypes along the transect, the stations were not subdivided. Consequently the F- statistic was not calculated for these sites. The water chemistry parameters that were determined, were found to be similar to those in the channel areas of the other transects in the pool.

Transect DD (River Mile 685.0)

The stations on transect DD were divided into the following three groups:

1. Stations 1-18 (Shallow open pool with intermittent islands).
2. Stations 19-21 (Channel)
3. Stations 22-31 (Shallow open pool with intermittent islands).

The subgroups of stations along this transect demonstrated significant differences between the means of all parameters measured. Little ecological significance was placed in some of the differences. Dissolved oxygen and temperature differences were probably due to differences in the time of day that the stations were sampled. The higher conductivities were again noticable on the Wisconsin side of the river and apparently reflect differences in water supplies to the river. However, nitrogen and phosphorus levels were recorded in the areas adjacent to and exclusive of the main channel. Apparently, as in the upstream transect previously discussed, these elevated levels reflect the increased amount of biological activity in these areas. (Table All)

More importantly, however, is that they reflect the accumulation of nutrients in these areas.

Benthos

The benthic community inhabiting the area of transect BB was variable in standing crop and number of species present. The lowest standing crops were found in the channel (Figure 10 , Table A12), with a maximum of 4.123 g/m^2 at station no. 4. The populations in the channel were composed of the least number of species. The dominant organisms by number were members of the Families Heleidae and Tendipedidae (Diptera). Benthic standing crops were considerably higher at the remaining 46 stations on this transect, but were variable. Molluscs and members of the Family Ephemeridae (Ephemeroptera) accounted for the high standing crops at several stations. The standing crops of benthos appeared to be unrelated to the amount of rooted vegetation present at any given station. Whereas it is difficult to determine whether any specific physical or chemical parameter is related directly to benthic standing crop, the most significant controlling factors are depth, and current velocity. The effects are not direct, but rather, affect the sediment type found at the stations. The data indicate that sediment particle size and the amount of organic material present are directly related to the benthic standing crops. Organic ooze is much more productive than are the inorganic fine and medium sand sediments.

The running and stagnant slough area on Transect BB (Stations 7-37) are variable in their benthic standing crops, but again reflect differences

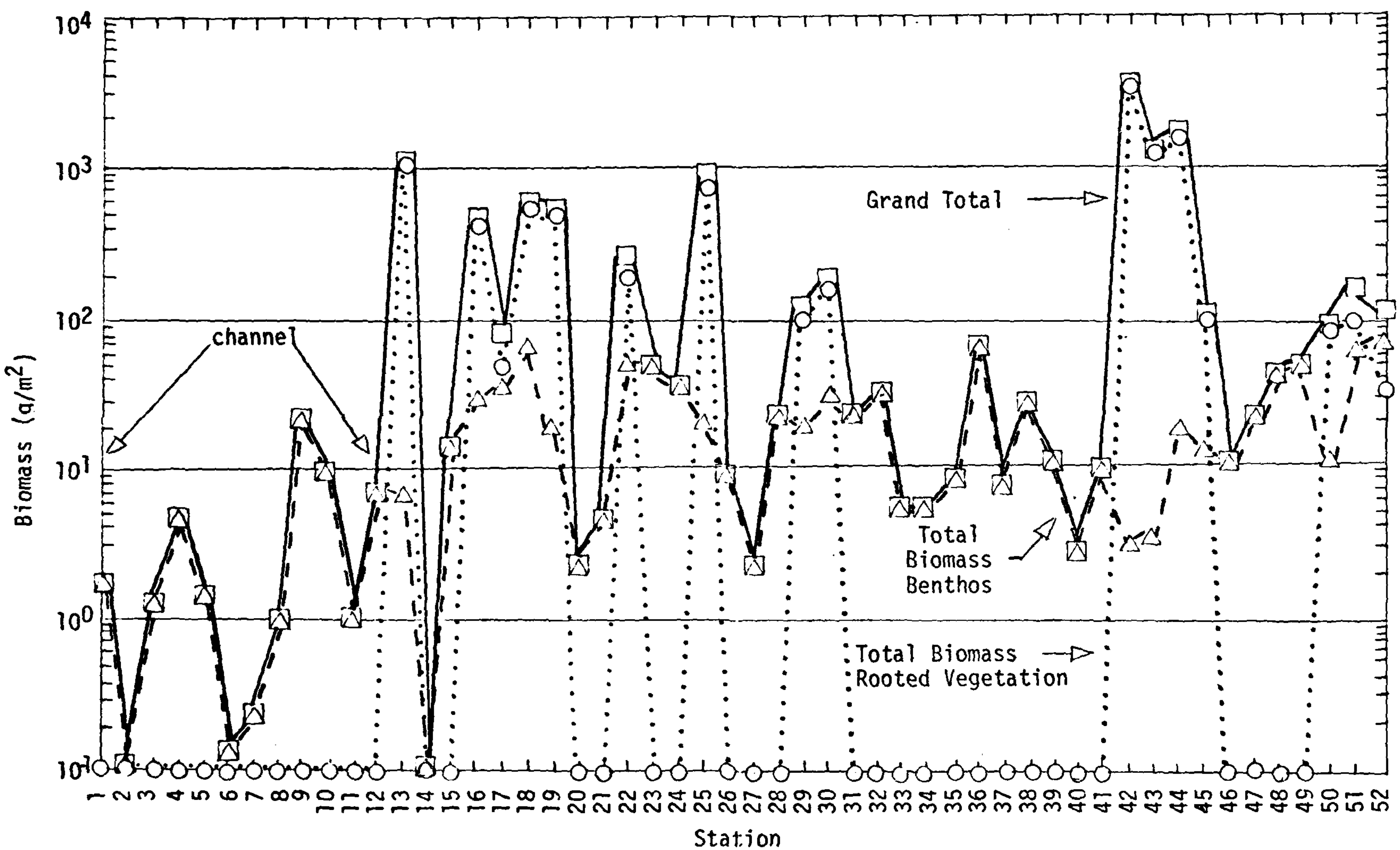


Figure 10. Biomass of Benthos (g/m^2), rooted vegetation (g/m^2), and total in Transect BB, Pool No. 8, 1973

in water supply. Current velocities in this area are also variable. The Goose Island Park area (Stations 38-52) were more homogenous with respect to the benthic standing crops, reflecting a similar homogeneity in the habitat type. Rather large expanses of open water characterize this area. Current velocities are concurrently low, and organic sediments have been allowed to accumulate in the absense of flushing activity from the distantly located channel. (Tables A21-A72).

The rooted vegetation on this transect was also variable. A survey was conducted during the summer of 1973, to determine the species composition and distribution of these organisms.

The maps accompanying this section describe the BB transect across Pool No. 8. The land masses are blackened with water masses appearing white. The vertical line intersecting the horizontal transect line marks the location of the station described on that page.

BOTANICAL SURVEY OF THE B TRANSECT, POOL 8

This survey attempts to characterize precisely the vascular flora of the B transects established by the River Studies Center of the University of Wisconsin-La Crosse on Pool 8 of the Mississippi River. The locations of the transects are shown in figures 1 & 2. I have personally identified all specimens collected. All specimens collected have been assigned collection numbers in the manner and fashion practiced by most professional taxonomists. A collection number refers to the specimens gathered from an individual plant. Obviously many duplicate specimens. all bearing the same number, can be gathered from a tree or shrub. The first set of all duplicate collections and all unicates are deposited in the herbarium of the University of Wisconsin-La Crosse, where they will vouch for the data reported here, as well as be utilized in continuing studies. All of the specimens retained have been appropriately mounted on standard 100% rag herbarium sheets. Duplicate sets of the collection will be distributed to other institutions to assure the safety of the collection and maximize its potential value. The nomenclature utilized follows that of Hartley (1966).

METHODS AND MATERIALS

The transects were followed with the aid of a compass. The transect line was followed over open water with a canoe, and

through marshes and alluvial forests on foot. The transects were visited during the early part of June and again in the middle of July. The rest of the summer was utilized to process the collections. There will thus obviously be some gaps in the report of late summer and fall flowering plants. All plants encountered within approximately 2-3 feet on either side of the transect line were collected. Notes were taken to record the plant associations encountered, for only representative specimens were collected from large monotypic assemblages, such as the frequently encountered colonies of Sagittaria rigida, the arrowhead. Trees along the transect lines were marked with paint or colored pieces of plastic and can be revisited in the future. All islands or land masses falling under the transects were arbitrarily numbered beginning at the navigation channel and proceeding sequentially east on the Wisconsin side and west on the Minnesota side. Therefore, for example, the third island crossed by the transect line east of the channel is designated as "Wisconsin Island 3." Open water, sloughs, and marshes are identified as lying between islands or on one side or another of one of them. As the channel in Pool 8 is pressed against the Minnisota shore, there are no reports of "Minnesota Islands." The one Minnesota island crossed by the transect in Pool 8, and shown on the navigation map, has been worn away to a thin line with a few trees. This lack of conformity of the areas, as they existed during the summer of 1973

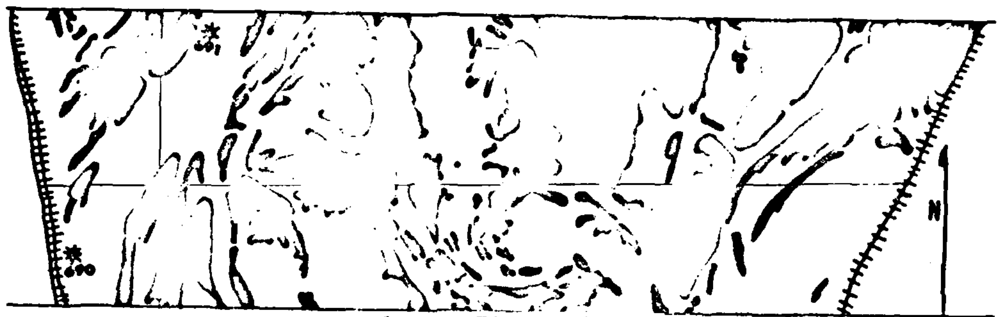
to what is shown on the maps occured frequently and probably testifies more to the rapidity with which changes are occuring on the River than to any negligence on the part of the map maker.

The results are reported for each transect separately. In all cases the report will list the plants collected on the given island or body of water that is identified on the map that heads each listing. Each time a taxon is listed, the specimen which vouches for the presence of the taxon in that locality is cited. The citations are always numbers which refer to my collection. Although a taxon may have been collected many times in a given area, it is only listed once. However, all the collections of that taxon, made in that area are cited in each list.

It must be emphasized that this report represents the result of a rigorous and complete assessment of the vascular flora of the transects. This is not merely a phytosociological survey and, although it may be difficult for the non-taxonomist to appreciate the value of the labour involved in preparing the specimens, every single plant reported herein is vouched for in our herbarium. An exception to this is Toxicodendron rydbergii, the poison ivy, to which I demonstrate an acute reaction and therefore could not collect. However, its presence was always noted when encountered. I believe this report is a significant contribution to the knowledge of the vascular flora of the Mississippi in general and to the environmental impact statement into which this report will go in particular.

VASCULAR FLORA OF TRANSECT B, POOL 8

1. 1st island on transect east of channel (Wisconsin Isl. 1). *Salix* and *Vitis* abundant on the drier, sandier portions of the island. Most of the ground cover *Phalaris arundinacea*. The remainder of the island alluvial forest.

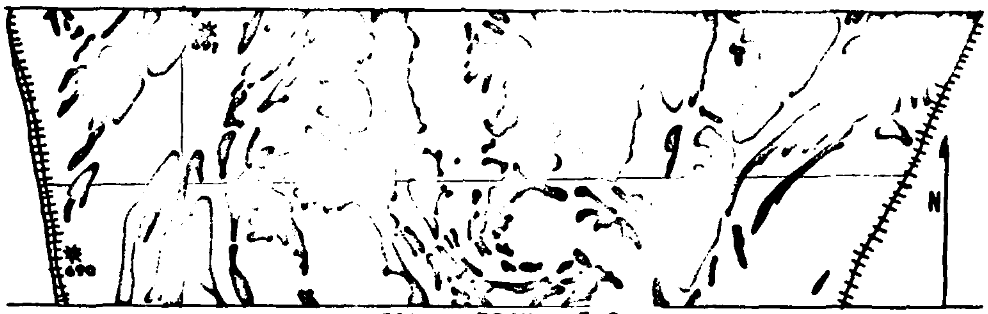


POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7454,7458,7459 7461,7477,7479 7504
Fraxinus pennsylvanica Marsh.	7468
Gleditsia triacanthos L.	7451,7473,7483 7492,7503
Populus deltoides Marsh.	7463
Salix amygdaloides Anderss.	7521
Salix interior Rowlee	7455,7457,7460, 7465,7467,7471, 7472,7474,7482, 7487,7489,7491, 7493,7495,7500, 7501,7510,7518
Salix pyrifolia Anderss.	7456,7475

Taxon	Collection No.
Salix rigida Muhl.	7525
Ulmus americana L.	7466,7502
Ulmus rubra Muhl.	7490
SHRUBS	
Cornus obliqua Raf.	7469,7512,7527
VINES	
Parthenocissus inserta (Kerner) K. Fritsch	7505,7506,7515 7523
Vitis riparia Michx.	7462,7464,7470, 7478,7480,7481, 7496,7499,7514, 7517,7522
HERBS	
Achillea millefolium L.	7494
Phalaris arundinacea L.	7452,7453,7485 7507
Poa pratensis L.	7520

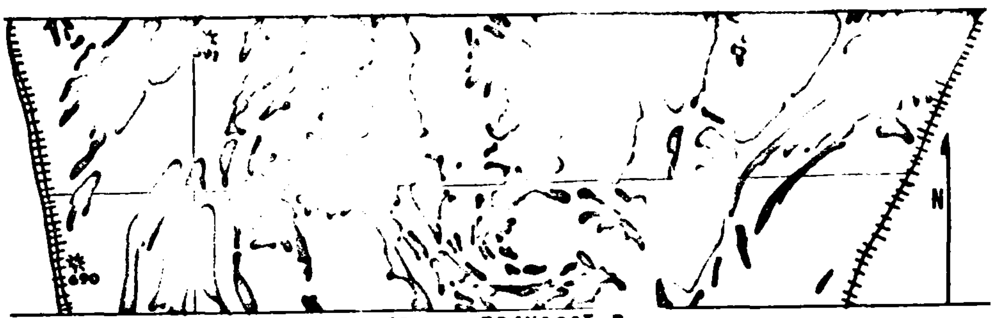
2. Wisconsin Island 2. Transect passed across narrowest part of island with 100% of the ground cover _Phalaris arundinacea_ and several mature _Salix interior_ and _Ulmus americana_. Alluvial forest.



POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Salix interior Rowlee	7545
Ulmus americana L.	7544,7546,7548
HERBS	
Phalaris arundinacea L.	7547

3. Bay east of Wisconsin Island 2. Ceratophyllum demersum and Potamogeton crispus most common.



POOL 8 TRANSECT B

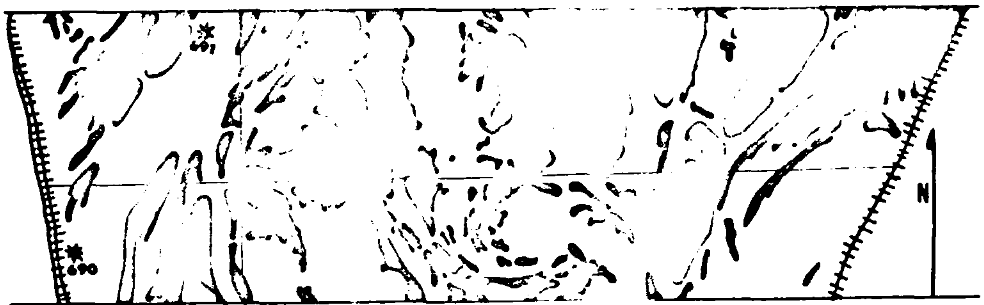
Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Elodea canadensis Michx.	7611
Potamogeton crispus L.	7613,7615
Potamogeton foliosus Raf.	7614
Potamogeton pectinatus L.	7612

4. Bay west of Wisconsin Island 3.

POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT AQUATIC PLANTS	
Ceratophyllum demersum L.	7609
Elodea canadensis Michx.	7606
Potamogeton crispus L.	7610
Potamogeton pectinatus L.	7601,7602
Sagittaria rigida forma fluitans (Engelm.) Fern.	7603,7604,7608
EMERGENT MARSH PLANTS	
Sagittaria latifolia Willd.	7607
Sagittaria rigida Pursh. (?)	7605

5. Wisconsin Island 3. This "island" had many sloughs running through it that are not given on the map. Ground cover was invariably Phalaris arundinacea. Dominant woody plants were Quercus bicolor, Cephalanthus occidentalis and Ulmus americana.



POOL 8 TRANSECT B

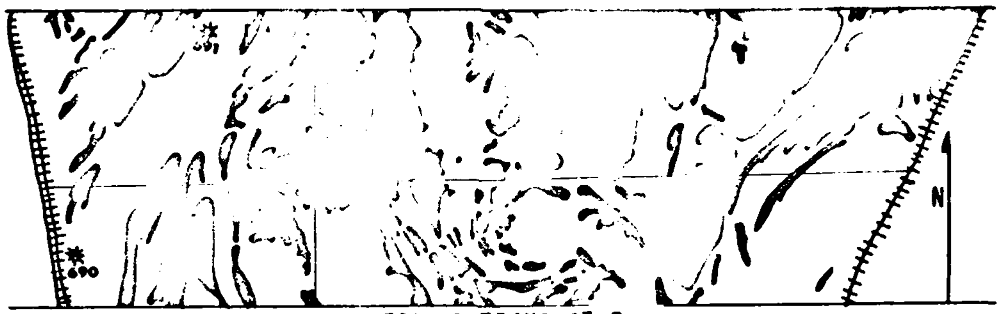
Taxon	Collection No.
TREES	
Quercus bicolor Willd.	7551
Ulmus americana L.	7550
SHRUBS	
Cephalanthus occidentalis L.	7549,7553
Cornus obliqua Raf.	7552

6. Slough between Wisconsin Islands 3 & 4. Aquatic vegetative mostly Ceratophyllum demersum and Potamogeton crispus.

POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7595,7599
Elodea canadensis Michx.	7597,7600
Potamogeton crispus L.	7584,7586,7587, 7588,7585,7596
Potamogeton zosteriformis Fern.	7583,7585,7596
EMERGENT, MARSH PLANTS	
Sagittaria latifolia Willd.	7591
Sagittaria rigida forma fluitans (Engel.) Fern.	7589,7590,7592 7593

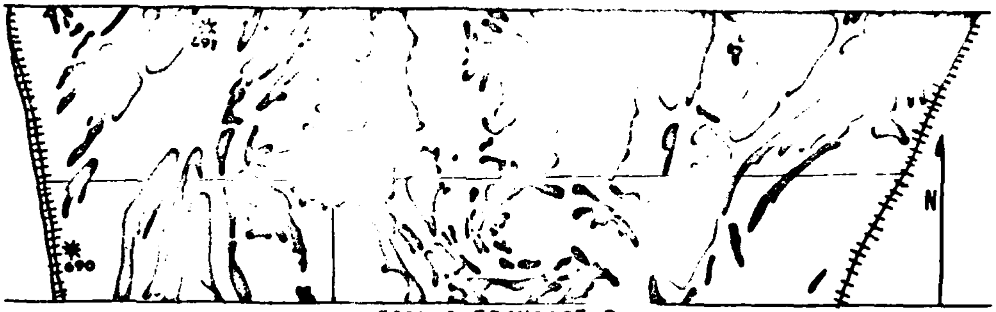
7. Wisconsin Island 4. Alluvial forest.



POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7576
Betula nigra L.	7568
Quercus bicolor Willd.	7572
Ulmus americana L.	7577
VINES	
Menispermum canadense L.	7582
Smilax herbacea L.	7570
HERBS	
Arisaema dracontium (L.) Schott	7571
Onoclea sensibilis L.	7596,7574,7575, 7580
Pilea pumila (L.) Gray	7578
Ranunculus abortivus L.	7573
Smilax ecirrhata (Engelm.) S. Wats.	7579
Viola cucullata Ait. (?)	7581

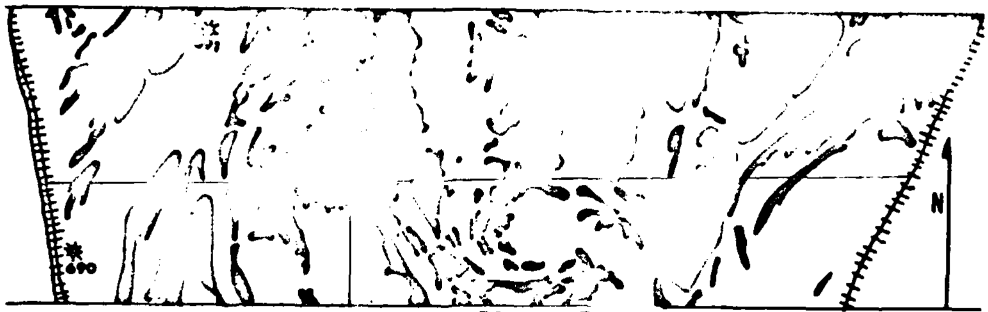
8. Bay between Wisconsin Island 4 & 6. Potamogeton crispus and P. pectinatus most abundant.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7531,7537
Elodea canadensis Michx.	7529,7539
Potamogeton crispus L.	7533,7535,7538, 7540,7541,7542
Potamogeton pectinatus L.	7530,7532,7536 7543
EMERGENT, MARSH PLANTS	
Sagittaria rigida Pursh, (?)	7538

9. Wisconsin Island 6. Alluvial forest with heavy ground cover of *Toxicodendron rydbergii*.



POOL 8 TRANSECT B

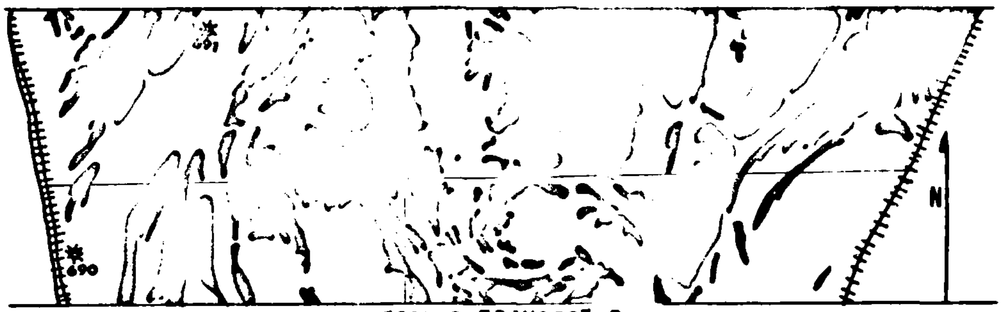
Taxon	Collection No.
TREES	
Acer saccharinum L.	7621
Fraxinus pennsylvanica Marsh.	7616
Quercus bicolor Willd.	7620
SHRUBS	
Cornus obliqua Raf.	7618
Sambucus canadensis L.	7623
VINES	
Parthenocissus quinquefolia (L.) Planch.	7627
Vitis riparia Michx.	7624
HERBS	
Arisaema dracontium (L.) Schott	7619,7629
Onoclea sensibilis L.	7617,7622,7625, 7626
Phalaris arundinacea L.	7628

10. Wisconsin Island 7. Alluvial forest that was still flooded at time of visit.

POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7556,7562,7564
Betula nigra L.	7567
Fraxinus pennsylvanica Marsh.	7561
Quercus bicolor Willd.	7555,7558,7566
Ulmus americana L.	7554,7558,7563
SHRUBS	
Cephalanthus occidentalis L.	7557,7560
Cornus obliqua Raf.	7565

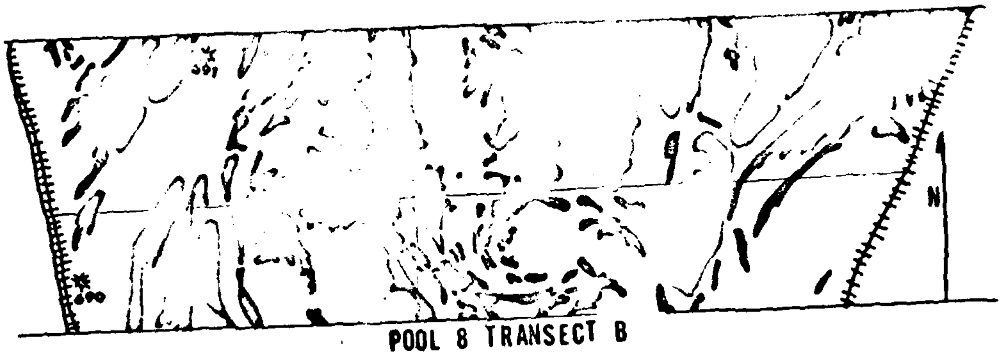
11. Bay between Wisconsin Island 7 & 8.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7673
Elodea canadensis Michx.	7672
Potamogeton crispus L.	7671
Potamogeton foliosus Raf.	7674
EMERGENT, MARSH PLANTS	
Phalaris arundinacea L.	7670
Sagittaria engelmanniana J G Smith (?)	7668
Sagittaria rigida Willd. (?)	7669

12. Wisconsin Island 8. Alluvial forest with ground cover nearly 100% Phalaris arundinacea.



POOL 8 TRANSECT B

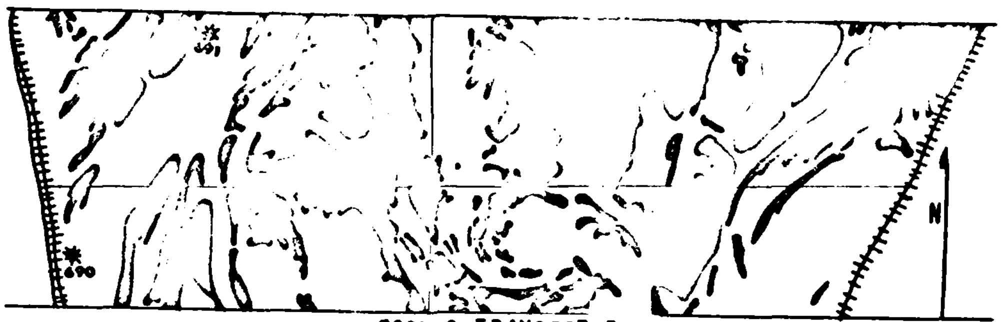
Taxon	Collection No.
TREES	
Acer saccharinum L.	7632,7641,7543
Betula nigra L.	7634,7637
Quercus bicolor Willd.	7630,7633,7638
	7639
Quercus bicolor Willd. with Q. macrocarpa Michx. introgressions	7631
SHRUBS	
Cornus obliqua Raf.	7640
HERBS	
Equisetum arvense L.	7635
Onoclea sensibilis L.	7644
Phalaris arundinacea L.	7642
Pilea pumila (L.) Gray	7645

13. Slough between Wisconsin Islands 8 & 9.

POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7663
Elodea canadensis Michx.	7664
Potamogeton crispus L.	7665
Potamogeton zosteriformis Fern.	7666,7667

14. Wisconsin Island 9. Alluvial forest with ground cover of <u>Phalaris arundinacea</u> in open areas and <u>Onoclea sensibilis</u> in shady areas of transect.



POOL 8 TRANSECT B

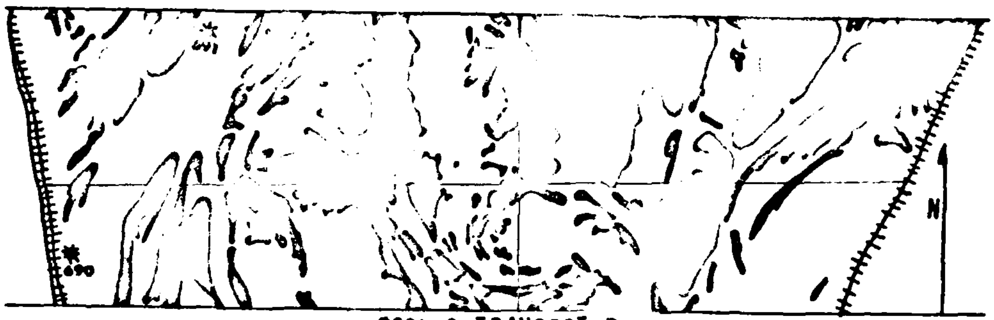
Taxon	Collection No.
TREES	
<u>Betula nigra</u> L.	7703
<u>Quercus bicolor</u> Willd.	7696,7697,7698, 7699
<u>Ulmus americana</u> L.	7704
VINES	
<u>Smilax herbacea</u> L.	7700
HERBS	
<u>Onoclea sensibilis</u> L.	7701,7702

15. Bay between Wisconsin Island 9 & 10. Mostly shallow water with marshes of Sagittaria and Phalaris. Potamogeton nodosus in deeper portions.

POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7649,7654
Elodea canadensis Michx.	7653,7655
Potamogeton crispus L.	7648
Potamogeton foliosus Raf.	7651,7652,7656
Potamogeton nodosus Poir.	7650
EMERGENT, MARSH PLANTS	
Phalaris arundinacea L.	7646
Sagittaria latifolia Willd.	7647

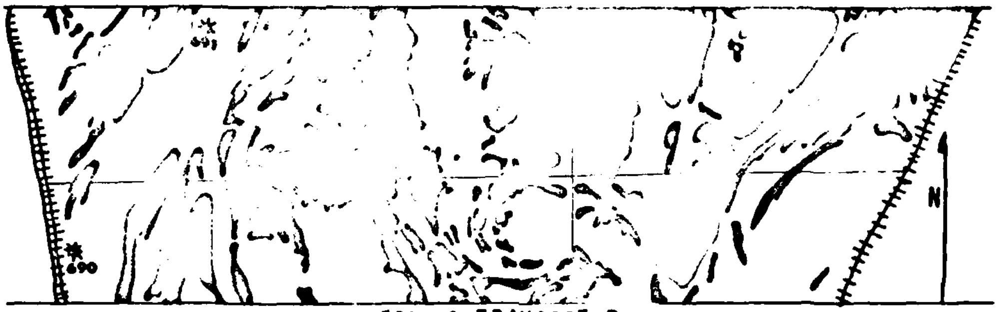
16. Wisconsin Island 10. Alluvial forest with sparse ground covers of Phalaris arundinacea (in sun) and Toxicodendron rydbergii (in shade).



POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7695
Betula nigra L.	7692
Quercus bicolor Willd.	7690,7693
Ulmus americana L.	7694
VINES	
Menispermum canadense L.	7691

17. Bay between Wisconsin Islands 10 & 11.



POOL 8 TRANSECT B

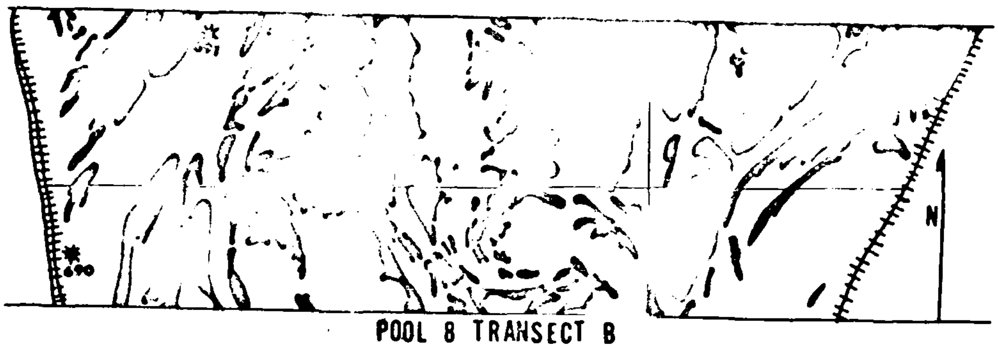
Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7686
Elodea canadensis Michx.	7687
Nymphaea tuberosa Paine	7685
Potamogeton crispus L.	7689
Potamogeton nodosus Poir.	7688
Potamogeton pectinatus L.	7685

18. Wisconsin Island 11. Alluvial forest with ground cover of *Phalaris arundinacea*.

POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7661
Betula nigra L.	7660
Fraxinus pennsylvanica Marsh.	7658
Salix rigida Muhl.	7657
Ulmus americana L.	7659,7662

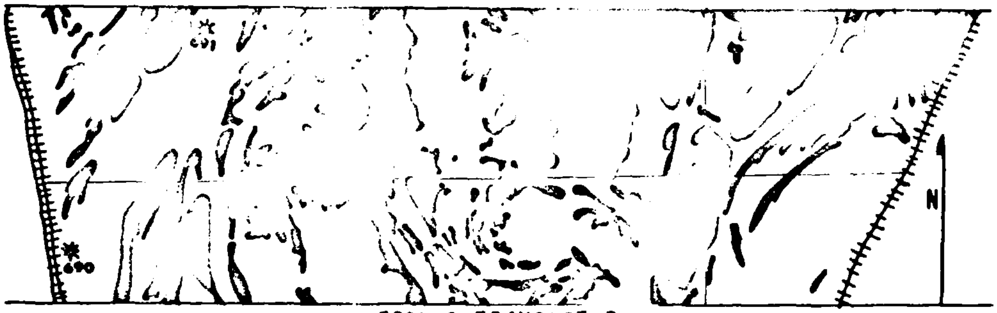
19. Bay between Wisconsin Islands 11 & 12.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7682
Elodea canadensis Michx.	7679
Potamogeton crispus L.	7683
Potamogeton foliosus Raf.	7677
Potamogeton nodosus Poir.	7678
Potamogeton pectinatus L.	7675
Potamogeton zosteriformis Fern.	7676
EMERGENT, MARSH PLANTS	
Sagittaria engelmanniana J.G. Smith (?)	7680
Sagittaria rigida forma *fluitans* (Engelm.) Fern.	7681

20. Wisconsin Island 12. Mature alluvial forest; transect passed over lowest portion. Rather diverse flora for an alluvial island.

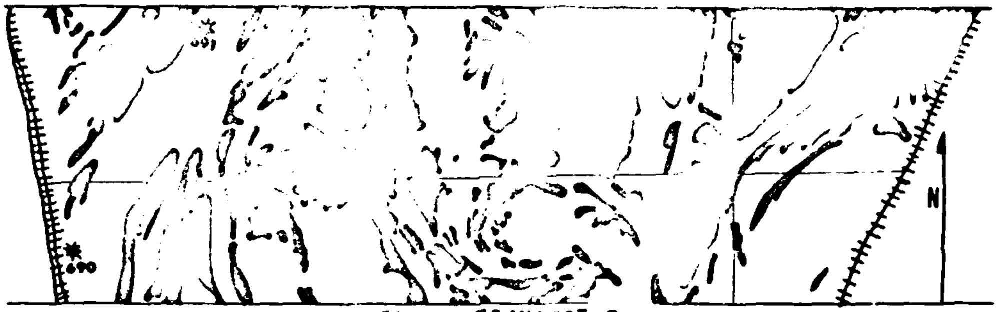


POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7747
Betula nigra L.	7727,7740,7744, 7748
Betula pumila L. var glandulifer Regel.	7765
Carya cordiformis (Wang.) K. Koch	7756
Gleditisia triacanthos L.	7730
Fraxinus pennsylvanica Marsh.	7739,7743,7755
Populus deltoides Marsh.	7767
Quercus bicolor Willd.	7729,7752,7766
Quercus rubra L.	7737
Ulmus americana L.	7742
Ulmus rubra Muhl.	7753
Zanthoxylem americanum Mill.	7769
SHRUBS	
Cornus obliqua Raf.	7741
Cornus racemosa Lam.	7750
Spiraea alba Du Roi	7762
Viburnum lentago L.	7763
VINES	
Menispermum canadense L.	7751
Parthenocissus quinquefolia (L.) Planch.	7760
Vitis riparia Michx.	7758

Taxon	Collection No.
HERBS	
Anemone canadensis L.	7734,7754,7772
Carex scoparia Schk. (?)	7735
Carex tribuloides Wahlenb. (?)	7746,7771
Equisetum arvense L.	7749,7761
Galium obtusum Bigel.	7732
Impatiens biflora Walt.	7764
Laportea canadensis (L.) Wedd.	7770
Oxalis stricta L.	7736
Pilea pumila (L.) Gray	7745
Phalaris arundinacea L.	7768,7773
Physalis heterophylla Nees.	7731,7757
Ranunculus abortivus L.	7733
Viola missouriensis Greene	7738

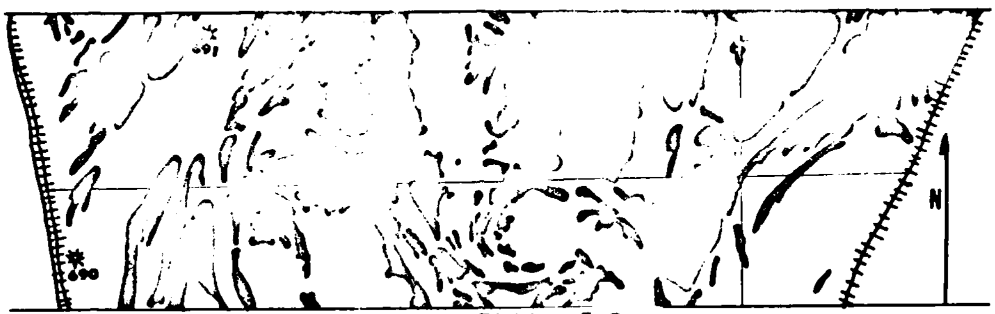
21. Mormon Slough between Wisconsin Islands 12 & 13. Center of Slough deep and devoid of rooted aquatic vegetation.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7795
Elodea canadensis Michx.	7784
Heteranthera dubia (Jacq.) MacM.	7797
Nymphaea tuberosa Paine	7791
Potamogeton crispus L.	7785
Potamogeton foliosus Raf.	7793,7794
Potamogeton nodosus Poir.	7783
Potamogeton pectinatus L.	7792
Potamogeton zosteriformis Fern.	7796,7798,7799
Vallisneria americana Michx.	7786,7787,7788, 7789,7790

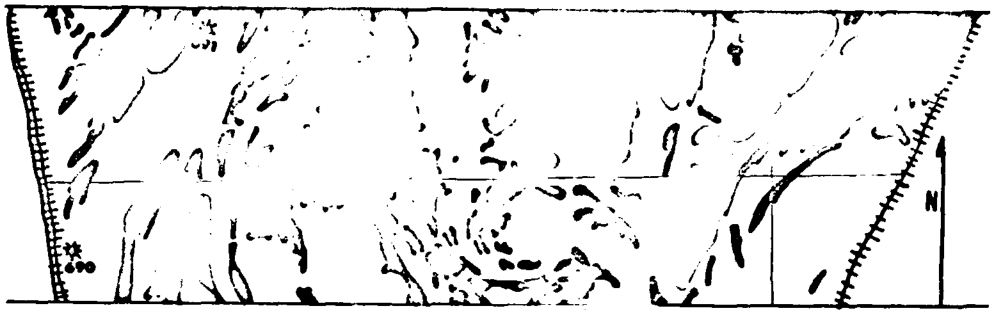
22. Wisconsin Island 13. A narrow island with Fraxinus pennsylvanica, Cornus, Asclepias incarnata, and Phalaris predominating.



POOL 8 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7778
Fraxinus pennsylvanica Marsh.	7779
Quercus bicolor Willd.	7775
Ulmus americana L.	7777
SHRUBS	
Cephalanthus occidentalis L.	7782
Cornus racemosa Lam.	7774
HERBS	
Asclepias incarnata L.	7776
Phalaris arundinacea L.	7780

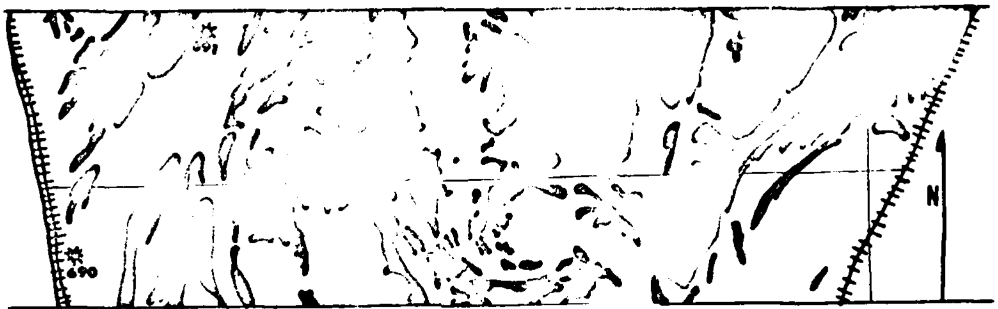
23. Bay between Wisconsin Island 13 & 14.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7808
Elodea canadensis Michx.	7806
Heteranthera dubia (Jacq.) MacM	7809
Nelumbo pentapetala (Walt.) Fern.	7803
Nympheae tuberosa Paine	7804
Potamogeton crispus L.	7805
Potamogeton foliosus Raf.	7807
Potamogeton pectinatus L.	7810
Potamogeton zosteriformis Fern.	7811.7812,7813, 7814
EMERGENT, MARSH PLANTS	
Sagittaria latifolia Willd.	7800,7801
Sagittaria rigida Pursh.	7802

24. Stump field between Wisconsin Island 14 and Wisconsin shore.



POOL 8 TRANSECT B

Taxon	Collection No.
SUBMERGENT AQUATIC PLANTS	
Ceratophyllum demersum L.	7718,7719
Elodea canadensis Michx.	7712
Myriophyllum exalbescens Fern.	7709,7710,7711
Nymphaea tuberosa Paine	7706
Potamogeton crispus L.	7713
Potamogeton foliosus Raf.	7716
Potamogeton nodosus Poir.	7714
Potamogeton pectinatus L.	7715,7725
Potamogeton zosteriformis Fern.	7720,7721,7722, 7723,7724
Ranunculus circinatus Sibth.	7705
Villisneria americana Michx.	7717
EMERGENT MARSH PLANTS	
Sagittaria rigida Willd.	7708

There are three major classifications vascular plant habitats utilized for this study. They are defined and limited by water depth and/or duration of flooding and are: 1) areas covered with flood waters during part of the growing season, at least on some years; 2) areas covered with several to many feet of water during flood stage but reduced to shallow water or wet soil later in the growing season; 3) areas covered with more than 6 to 12 inches of water at all times, except, perhaps in instances of drought. the vascular plant communities present in these habitats are broadly defined for this report as alluvial forest, marsh, and submergent aquatic respectively. Trees always indicate alluvial forest, emergent herbs, most commonly the arrowheads, indicate marsh, and submergent vascular plants, such as species of Potamogeton, and Ceratophyllum demersum, indicate the submergent communities.

ALLUVIAL FORESTS

None of the land areas traversed by the transects are free from flooding. Exceptions to this statement would be the steep Minnesota banks and those portions of the islands adjacent to the channel that are built up by the deposition of dredge spoil. There were a total of 15 such land areas or islands on the transects ranging in width from several feet to over a mile. The particular associations of woody plants found on these islands will vary somewhat depending upon how often the islands or land areas in question are flooded and how long the flooding lasts. This would evidently be related directly to the elevation of the land areas or islands

in question. It has not been found profitable to seperate different associations of plants other than to state here that Betula nigra and Quercus bicolor appear to favor wetter situations and are relegated to the margins of alluvial islands once the soil has been built to a point where Ulmus americana and Acer saccharinum have invaded and become dominant.

The less often an island or land mass appeared to be flooded, judging from what was seen on the transects, the more diverse, relatively speaking, was the vascular flora. The greater the frequency and duration of inundation, the fewer the total number of taxa. Table A13 demonstrates the dominant members of the alluvial forest as determined by frequency of occurrence. This table, as all the others that follow, was obtained by determining the frequency with which a particular species was found in that habitat on the transects. Ulmus americana, for example, found at least once on 13 of the 15 alluvial islands or land masses crossed by the transects, is given the frequency index of .87. This is a very rough estimate of the frequency of occurrence of a particular species, but still, I believe, a very useful indicator. Tables A14, A15 and A16 give frequency values for alluvial forest shrubs, vines, and herbs respectively. This data is essentially the same manner of reporting this information as the present values of Curtis (1959).

MARSH

All emergent vegetation was defined as marsh vegetation. Indeed, the vegetation itself indicated the habitats herein defined as Marsh. This is vegetation that cannot withstand total submersion for relatively long periods of time, particularly not during the middle and later parts of the growing season, nor can it withstand relatively dry conditions for long. The most frequently encountered species in this habitat was Sagittaria rigida. Some shrubs are often found in marshes, as herein defined, on land masses slightly raised above the surrounding areas, in much the same manner as these taxa are often found as transitional between the marsh and the alluvial forest. These shrubs, such as Cephalanthus occidentalis and species of Cornus and Salix, were counted with the alluvial forest vegetation. Table A17 gives frequency data for the species found in this habitat.

SUBMERGENT AQUATIC

Ceratophyllum demersum, Elodea canadensis, and Potamogeton crispus were the most frequently encountered species in this habitat. This is clearly demonstrated in Table A18. Again, it is necessary to bear in mind that these figures represent gross frequencies only; they are in no way indicators of abundance at a particular site. Standing crop figures may be entirely different from these. It is interesting to note that one of the most frequently encountered members of this habitat, Potamogeton crispus, is not a native member of our flora. The original submergent flora of the undisturbed

Mississippi River and its natural pools must have been far different in terms of species composition.

Other aspects of the project, particularly maintenance dredging, has also resulted in the hinderance of stabilization of the river system, and is threatening many of the areas where the high recreational value exists. Three notable examples are: Crosby Slough (Mile 687-688), Coney Island, (Mile 689-690) and upper Pettibone Island (Mile 699-700).

Examination of the dredge spoil sites reveals the following:

1. That spoil deposited on the upper end of Coney Island is very unstable and washes either back into the channel or into the slough on the Minnesota side of the Island.
2. That spoil deposited at Mormon Slough is threatening to close that water passage into the upper end and the middle of Goose Island .
3. That spoil deposition at Crosby Slough is threatening to close the channel as a water supply for the upper open pool reach, a vital area for fish and waterfowl.

Crosby Slough Dredge Spoil Study

During the summer of 1973, a special dredge spoil study was conducted, to determine the immediate effects of spoil deposition and dredging activity in Pool No. 8.

Forty stations were established in the immediate vicinity of the dredge spoil site at Crosby Slough (Mile 690.2) Benthic samples and water chemistry determinations were made prior to, during, and immediately after dredging. The William A. Thompson was scheduled

to deposit approximately 130,000 cu. yds. of material on the island for this particular job. The stations were located upstream and downstream from the dredge spoil site (Figure 11). Each station was sampled four times during the experiment. The first set of data (8S-1) was collected four days prior to dredging activity. The second and third sets of data (8S-2, 8S-3) were collected during the period when dredging was occurring. The fourth set of data (8S-4) was collected one week after completion of dredging.

A time series analysis of variance (F-distribution) was calculated for the means of all parameters collected on the four days. Significant differences were noted between the means of the following parameters collected on the four dates: Temperature, turbidity, nitrate nitrogen, nitrite nitrogen, and dissolved oxygen.

No ecological significance is placed on the differences in temperature and dissolved oxygen, in the sense that they were affected by dredging. Rather, they are probably a function of diurnal changes and appear because the stations were sampled during different times of the day. The turbidity increase however is related to dredging. (Table A11-A). The operation of the dredge and tender boats in a rather confined area created disturbances, resulting in the increase. This is supported by direct observation. However, the greatest contributor to the increase in suspended particles was probably the runoff the the dredged material from the spoil site.

The increase in nitrate and nitrite nitrogen levels after dredging is also related to the activity occurring on the site.

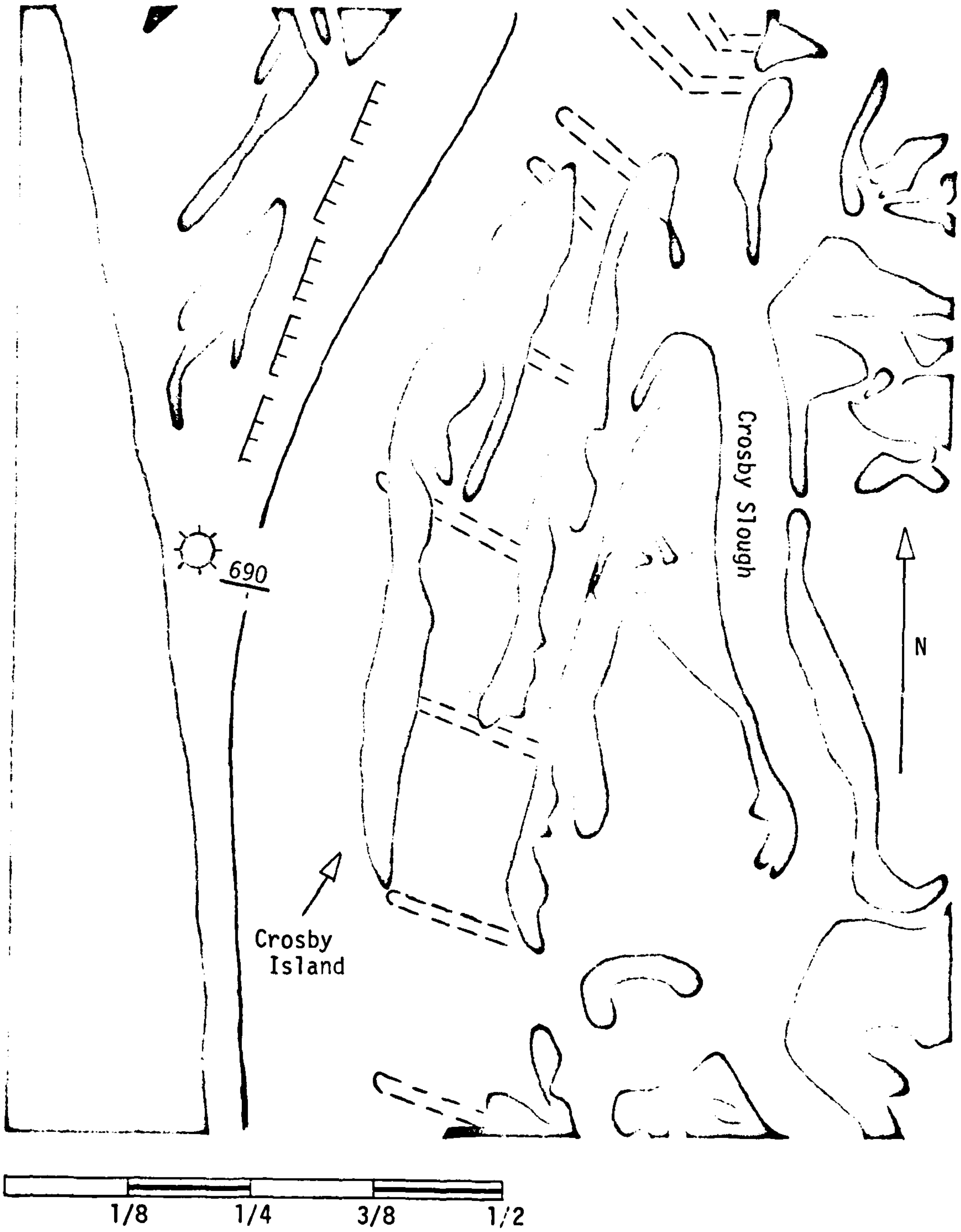


Figure 11. Map of Crosby Island, Navigation Pool No. 8, 1973.

The source of nitrogen, however, was not identified. The ambient nitrogen levels in the channel areas where dredging occurred, was relatively low and probably cannot be accountable as the source of the increased nitrogen levels in the downstream water. However, the development of a plant community on the spoil site during previous years has resulted in the accumulation of nitrogen in the poorly developed soils. Leaf litter and other forest floor materials have accumulated. It appears then, that the runoff of the dredge slurry from the site during dredging has leached some of these nitrogenous materials from the site and apparently has deposited it in downstream waters.

In summary, the effects of dredging on water chemistry at the Crosby Slough area appear to be localized. That is, significant downstream changes in the chemical parameters measured would not appear to have long term consequences. The act of dredging constitutes a local disturbance that becomes normalized in a relatively short period of time. However, the physical consequences of the placement of spoil material are great and will be discussed separately. This placement of material on Crosby Island resulted in the complete overlaying of the existing soil that had developed prior to dredging. In addition to this, the existing plants on the island, with the exception of willow trees, were completely covered or killed at the immediate spoil site. This obviously constitutes habitat destruction, and results in the complete eradication of the existing ecosystem operating on the site. Equally important, the general state of instability of the spoil material with regard to wind and water erosion, places in jeopardy, areas that are

situated close to the spoil site. In the case of Crosby Slough, the small channel located just east of the spoil site has begun to fill with sediments from the runoff of the spoil material, and will probably continue to fill from future wind and water erosion. This is supported by the benthos data collected at the site during the summer of 1973. Samples collected before and after dredging indicate that there has been a 100-300% reduction of organisms (by weight) at the most sensitive sites close to the spoil site. In particular, mayflies and clams and snails were the most affected (see data supplement). Obviously this was due to the overlaying of productive sediments with sand and rendering them unproductive.

SOCIOECONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for Pool 8 are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the study area of the Upper Mississippi River divide into the industrial, recreational, and cultural effects.

Industrial Impacts

In contrast to some pools in the study area that have had limited industrialization along their banks, Pool 8 has had a significant amount and is the origin or destination of a portion of the commodities that move through the pool. The result is that the industrial impacts of operating and maintaining the nine-foot channel in Pool 8 have been important. The principal industrial impacts are:

1. Increase in employment as a result of the seven commercial docks located in Pool 8.
2. Increased turbidity of water in some portions of the Upper Mississippi River due to barge movement.
3. Additional employment due to the operation of Lock and Dam 8.

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4. An initial increase in commercial fishing and trapping because higher water levels caused increased acreage of suitable fish and fur-bearer habitat. More recently, a potential decline in commercial fishing because recent improper dredge spoil placement has reduced suitable fish habitat.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel and its associated locks and dams by the Corps of Engineers are the through-traffic link for commodities moving up and down the river, the employment in lock and dam and commercial dock operations, and an initial increase in the potential for commercial fishing and trapping. The detrimental effects are a decline in water quality due to river barge movement and spills and with continued improper dredge spoil placement a likely decline in commercial fishing.

Recreational Impacts

1. An increase in recreational boating due to stable, navigable water levels which leads directly to more recreation facilities and their accompanying employment.
2. An immediate increase in sport hunting and fishing due to an increase in --

   a. Waterfowl habitat, and

   b. Fish spawning areas resulting from rising water levels.

Again, as with commercial fishing cited above, improper dredge spoil placement has recently had a detrimental effect on sport hunting and fishing.

3. An increase in sightseeing visitors to the locks and dams at both ends of the pool.

Cultural Impacts

No archaeological, historical, or contemporary sites of cutural significance in Pool 8 are known to have been affected by Corps' operations.

Discussion of Impacts

The industrial, recreational, and cultural impacts identified above are examined in detail in the following three sections. Resource implications of these three socioeconomic impacts are discussed in Section 6.

Industrial Activities

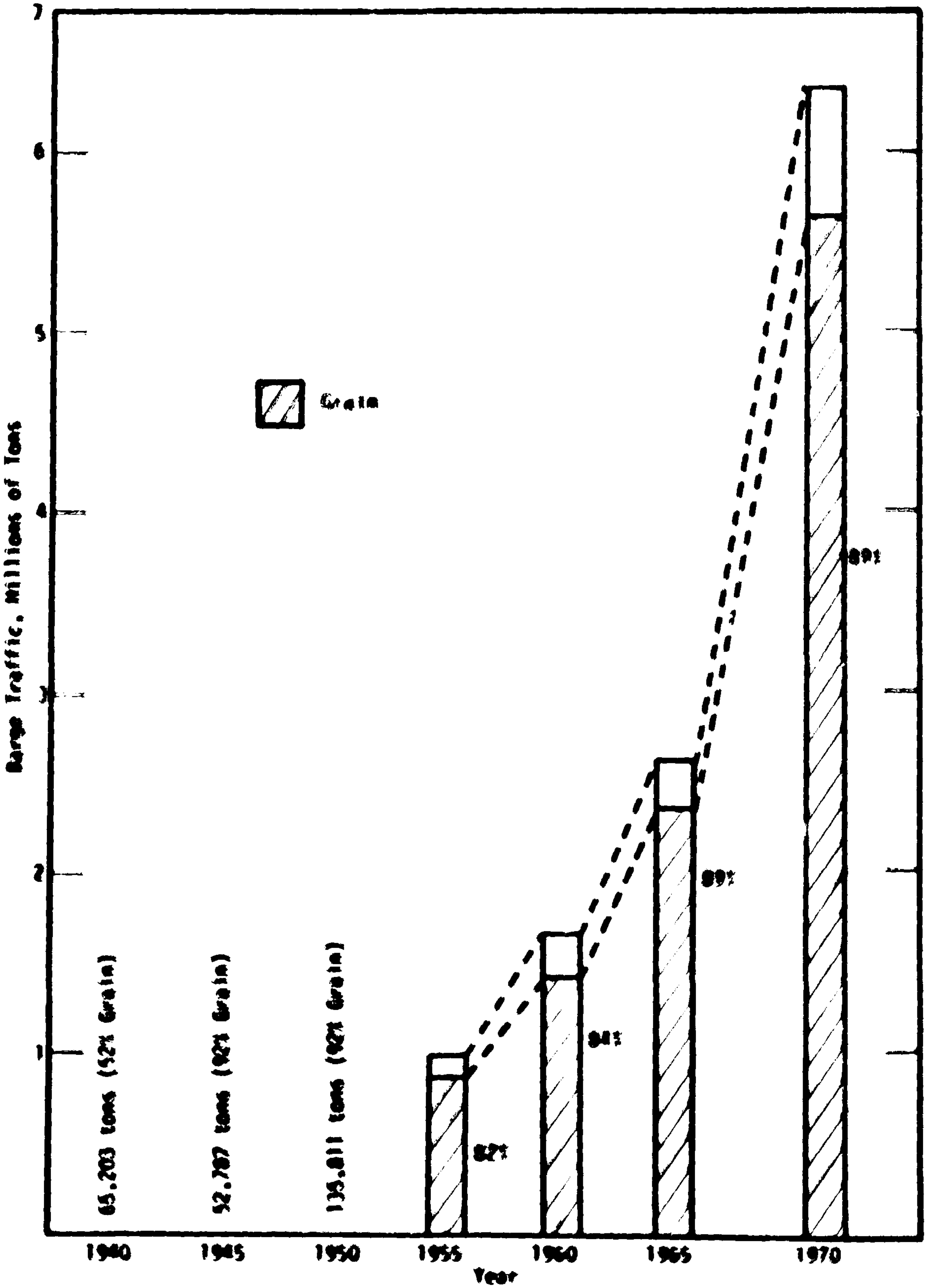
The economic effect of the activities of the Corps of Engineers on the Mississippi River in the St. Paul District can be measured mainly in terms of three major elements. They are:

1. The channel itself with its associated locks and dams and navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms the impact of the Corps' activities in Pool 8 is not as great as in some of the other pools in the Northern Section of the Upper Mississippi River.

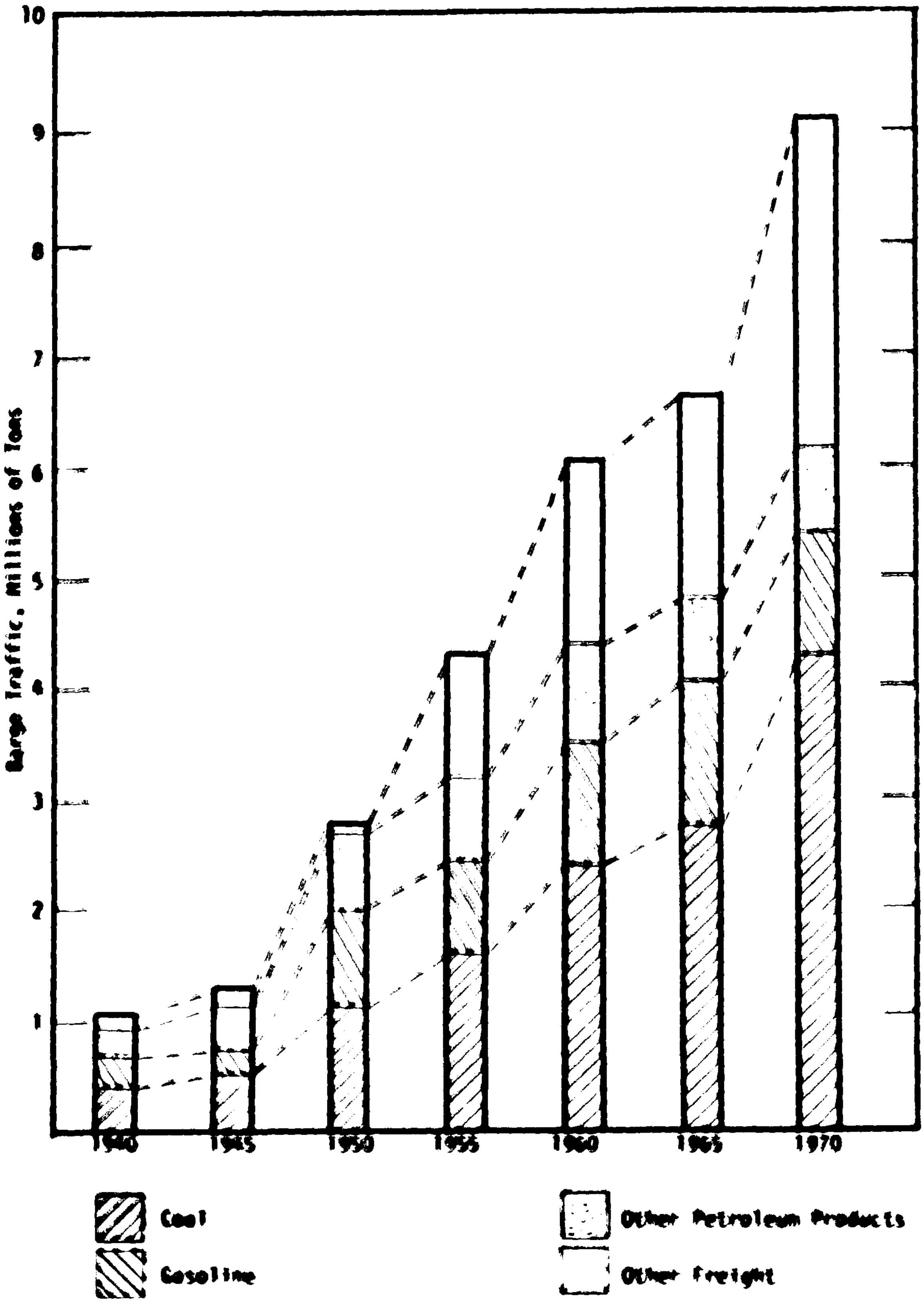
Barge Activity. The greatest and most obvious impact of the activities of the Corp of Engineers in Pool 8 has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g., locks and dams and seven commercial docks and terminals) on the shores and the barge tows moving along the river. However, Pool 8 is not the origin of the terminal for any of the commodities that move in barges along the Upper Mississippi River. Rather, it serves as an important water link between important commodity terminals upstream and downstream from it.

Figures 12 and 13 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures illustrate the diverse economic activity within the St. Paul District; this diversity is also generally true of Pool 8 whose seven commercial docks handle all of the commodities shown in the figures. However, the bulk of the commodities shown in Figures 12 and 13 flow through the pool enroute elsewhere. Although receipts in the St. Paul District still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three



Source: Based on data from U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota.

Figure 12. Shipments Out of the St. Paul District



Source: Based on Data from U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota

Figure 13. Receipts of Major Commodities -- All Ports, St. Paul District

decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMREBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently, however, the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 8 and Lock 7 -- the locks at either end of Pool 8 -- which are shown in Figure 5. From 1960 to 1972 commercial lockages through Lock 8 increased by 28 percent and those through Lock 7 increased by 83 percent.

Commercial Dock Facilities. Firms that depend heavily on the river often maintain riverside facilities. Pool 8 contains seven commercial docks and terminals, including four that supply coal and petroleum to Northern States Power Company, Socony Mobil, Texas Oil Company, and La Crosse Coal Company. Another transships grain for Cargill Company.

Behind many of these docks are installations and storage facilities that are dependent upon them. Thus, the ramifications of river navigation reach into the entire economy of the region surrounding Pool 8. Employment directly and indirectly connected to these industries is important to the regional work force.

Commercial Fishing. Pool 8 is a major source of commercial fishing in the Northern Section of the Upper Mississippi. After Pools 4 and 9, Pool 8 produces more fish for commercial purposes than any other.

Table 5 shows the annual commercial catch for most years from 1960 through 1969. Some wide fluctuations occurred during the decade -- the peak catch being 1,192,000 pounds in 1962.

However, even with the wide year-to-year variation in commercial fishing in Pool 8 shown in Table 5 , the level of commercial fishing is greater than prior to the lock and dam construction. This increased commercial fishing in Pool 8 since the lock and dam construction is at least partially due to the beneficial impact of a larger area of fish habitat caused by the rising water level. However, in recent years improper dredge spoil placement and sedimentation below wing dam has reduced fish habitat. Some experts on river fishing believe that major year-to-year variations in commercial fish catches are less affected by the supply of fish in the river than by market demand, as reflected in prices commercial fisherman receive for their catch. For example, high meat prices in mid-1973 have caused fish prices to increase with an attendant increase in commercial fishing activity on the river (Fernholtz, personal communication).

Table 5. Commercial fishing, average catch per unit effort with setlines, gill nets, and seines, and total pounds caught per year Navigation Pool No. 8, Upper Mississippi River.

YEAR	Set Line	Gill Net	Seine	Total Pounds
1953	10.80	0.13	0.48	375080
1954	10.00	0.22	0.31	369220
1955	16.06	0.16	0.55	436420
1956	7.45	0.20	0.67	462983
1957	10.86	0.13	0.49	93559
1958	9.47	0.19	0.48	487154
1959	12.47	0.23	0.90	633991
1960	11.12	0.25	1.68	764697
1961	13.66	0.35	0.90	921613
1962	8.98	0.11	2.20	1144425
1963	12.35	0.14	1.50	645545
1964	13.94	0.16	2.42	1063069
1965	12.44	0.21	5.23	860506
1966	14.59	0.20	3.28	790769
1967	14.93	0.15	5.10	860269
1968	15.24	0.17	8.66	670758
1969	15.73	0.20	3.96	553622
1970	16.46	0.29	6.14	782864
1971	20.41	0.28	7.00	1019762

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and other recreational activities.

Boating Activities and Related Facilities. For Pool 8 the best available measures of pleasure boating activity are records of pleasure boats locking through Locks 8 and 7 -- the locks at each end of the pool. These data -- along with the total pleasure-boat lockages through these two locks -- are shown in figure 8 for the years 1960 to 1972. The table shows significant increases in pleasure craft locking through both Lock 8 (from about 4,000 in 1960 to about 5,600 in 1972) and Lock 7 (from about 6,800 to 9,200 during the period). The table also shows an accompanying increase in the number of pleasure boat lockages at both locks during the period although the increases have not been as dramatic as for the number of pleasure boats moving through the two locks because several pleasure boats can be handled in each lockage.

The nine-foot channel and associated locks and dams have provided stable water levels that have contributed significantly to the increased boating activity in Pool 8, as have increased regional population, higher levels of family income, and more leisure time.

A variety of physical facilities have been developed in Pool 8 that exist mainly to serve boaters and fishermen using the

pool. These include:

Facility	Number
Small boat harbors, marinas, boat clubs	2
Recreational sites	3
Public boat launching sites with parking areas	22
Commercial recreational sites	12
Wildlife refuges	2

Except possibly for the recreational sites without ramps, which do not cater primarily to boaters, these facilities generally result from Corps' operations on the river that constituted the channel and stable water levels.

Particularly noteworthy is the large number of public boat launching sites with parking areas in this pool that testifies to the great importance of the river as a recreational resource.

Sport Fishing, Hunting, and Other Recreational Activities

The size of the pool and the variety of access points and the lack of an adequate survey program have precluded obtaining an accurate count of pool visitation for past years. Neither the Wisconsin Department of Natural Resources (Fernholz, personal communication) or the Minnesota Department of Natural Resources (Golden and Sternberg, personal communication) nor the U. S. Bureau of Sport Fisheries and Wildlife (Chase, personal communication) have recent, continuing data on sport fishing, sport hunting, and other

recreational activity for Pool 8. The most precise data available are for 1963 and appear in Table 6 . The data are a composite of both Corps of Engineers and Bureau of Sport Fisheries and Wildlife (from the upper Mississippi River Wildlife and Fish Refuge) visitation compilations for that year. In addition to being the most accurate data available to date, they are the most usable since visitation survey estimates were broken down to show ratios of participation in the seven most appropriate activities on an annual and peak month basis. Total annual visitation to Pool 8 in 1963 was estimated at about 300,000 which was the highest for any pool in the St. Paul District and represents the equivalent of about three visits for each of the 100,000 people residing in the area of the pool (St. Paul District, November, 1967).

Visitation during the peak month of July, 1963 was estimated at about 78,000 or more than 26 percent of the annual visitation. Table 6 shows a breakdown of total annual visitation and peak month visitation by activities. Visitation for hunting appears only under the annual category since it does not occur in the summer months and does not influence determination of summertime peak loads. It is estimated that about 60 percent of the total visitation shown in Table 6 is generated at or through avialable public-use sites. With the possible exceptions of camping and picnicking, the other five activities cited in Table 6 , which account for over 90 percent of the total participation, are water-related. It seems reasonable to conclude that the higher, stable

Table 6. Pool 8 total visitation - 1963

Activity	Annual 1963		Peak periods		
	Percent of total	Activity participation	Percent of total	Activity Participation Month (Jul)	Peak Day
Camping	1.5	4,500	2.5	1,950	150
Picnicking	7.0	21,000	10.4	8,110	610
Boating	32.0	96,000	38.0	29,640	2,230
Fishing	48.0	144,000	40.0	31,200	2,350
Water skiing	1.8	5,400	2.3	1,800	140
Swimming	4.5	13,500	6.8	5,300	400
Subtotal	94.8	284.400	100.0	78,000	5,880
Hunting	5.2	15,600	---	10,920 (Oct)	820 (Oct)
Total annual	100.0	300,000	---	---	---

Source: St. Paul District of the U.S. Army Corps of Engineers. November, 1967. Page 20.

water level in Pool 8 resulting from the construction of Lock and Dam 8 has had a favorable impact on these five activities.

The Winona District of the Upper Mississippi River Wildlife and Fish Refuge has collected public-use data on the portion of the refuge that lies in Pools 7 and 8. These data appear in Table 6 These data again emphasize the importance of the river as a recreational resource for fishermen, water-sport, and camping activities -- about 80 percent of the visitors using the river for these purposes.

Another source of data on sport fishing is available because attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available appear in Figure 9. The table shows some variation in sport fishermen observed from Lock and Dam 7 and 8 since 1960. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 8 are in Pool 9. Fishermen in Pool 8 -- as seen from Lock and Dam 7 fluctuated by about 10,000 people during the period from 1960 to 1970. However, it should be emphasized that these data are not precise and only an index to sport fishing activity in the pool.

In terms of impact on sport fishing, the higher water level in Pool 8 has increased the spawning areas for fish. In theory

this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 8 may be partially offset by river pollution and turbidity from barge activity in it. Also in recent years improper dredge spoil placement has reduced the acreage of available fish habitat in Pool 8, and sedimentation has also hurt fish habitat -- particularly in areas below wing dams. Therefore, Corps' operations following the construction of Lock and Dam 8 have had both positive and negative effects on fish (and also waterfowl) habitat in the pool.

As the water level in Pool 8 was raised by Corps' operations, habitat for residential and migratory waterbirds was initially increased. As with fish habitat, improper dredge spoil placement in recent years has also reduced waterfowl habitat. This suggests the potential for greater bird hunting adjacent to Pool 8. Some measure of hunting activity in the pool is shown in Table 6 that notes 15,600 hunting visits to Pool 8 in 1963.

Recreational sites along the perimeter of Pool 8 also facilitate sightseeing, picnicking, hiking, and camping. While non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities. In addition, visitors of overlooks at locks and dams are a direct result of Corps' operations.

Cultural Impacts

Conversations with the State Archaeologists for Minnesota and Wisconsin (Streiff and Freeman, personal communications) revealed no evidence to indicate any cultural impacts on sites in Pool 8 through the activities of the Corps of Engineers.

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4. UNAVOIDABLE ADVERSE EFFECTS

The unavoidable adverse effects are those that are associated with the following:

1. The actual filling of the pool and subsequent inundation of acres of existing habitat.

2. The changes in the existing aquatic habitats associated with the conversion of a riverine habitat to a lacustrine type habitat.

3. The creation of increased surface area of water in the river basin.

4. The alteration of water current patterns primarily in the middle and lower portion of the pool.

5. The deposition of sand and silt from maintenance dredging activities in areas that are biologically productive.

6. The diversion of water away from the Reno bottoms area immediately downstream from the earthen dike at Genoa, Wisconsin.

Occasional field observations indicate that Navigation Pool No. 8 possesses a nutrient cycle similar to that found in Pool No. 7 but perhaps not to the same degree. Nitrogen levels fluctuate on an annual basis.

7. The presence of the lock structures and dam across the entire river, acts as a barrier for the upstream and downstream movement of organisms. Many species of fish undergo a migratory phase sometime during their life, usually prior to spawning in most species. The

interruption of these migrations, no doubt, has had an effect on several species. However, data are not available at this time.

Maintenance dredging activities in the pool have had an adverse effect, in that sediments suspended in the water as a result of spoil placement are accumulating in many of the most environmentally valuable parts of the pool. Whereas maintenance dredging is required for project maintenance, alternatives seem to be available to the present methods employed.

5. ALTERNATIVES

The phases of the project that have the greatest number of alternatives available is the maintenance dredging operation. With the one foot maximum drawdown policy adopted, normal day to day water level fluctuation may be insignificant. The deposition of dredge spoil on the other hand, has had a drastic impact on the biological systems operating in the pool.

Possible options are:

1. The application of dredging equipment capable of depositing spoil material greater distances from the channel (removal from the floodway).

2. The stabilization of spoil material by containment structures, to increase the rate of recolonization of the area by native plants.

3. The containment of material to prevent its rapid return to the channel during periods of high water.

4. The encouragement of beneficial and practical uses of spoil material by business and agencies, both public and private.

5. The complete removal of the spoil material from the immediate river basin.

6. The initiation of remedial dredging operations to enhance areas that have been adversely affected by previous maintenance dredging, directly or indirectly.

6. RELATIONSHIPS BETWEEN SHORT TERM USES OF MAN'S ENVIRONMENT AND LONG TERM PRODUCTIVITY

The increases in population in the upper Mississippi River basin created a greater demand for the commercial use of the river, and subsequently led to the construction and maintenance of the nine-foot navigation channel. The impact of increased navigation and commerce on the river has in turn, resulted in a greater population density in the same area. With this increase in population came an increase in land use for agricultural and urban development, and subsequently resulted in vast increases in the amount of sediment entering the Mississippi River through tributary streams. The construction of the nine-foot navigation channel during the 1930's resulted in the removal of vast areas of low wetland forest and meadow, and in turn created large shallow pool areas, for fish and wildlife habitat. The increase of man's activities tended to fill these areas. If this rate of filling in the pool areas remains constant, the creation of wildlife and fish habit during the early years of the project should in fact, be categoriz a short term benefit. That is, measured in years of the projected life of the nine-foot channel, these areas will cease to be usable habitats as we know them now.

The creation of the navigation pools also resulted in an increased hydraulic efficiency within the channel areas and diverted water from backwater areas. This accounted for the increase in the state of

eutrophy in most of the middle and lower pool areas, in that it allowed nutrients to accumulate at a rate probably much higher than was projected. This tendency toward a eutrophic state in these areas has, no doubt, been reinforced by the recycling of autochthonous materials due to the rapid establishment and growth of populations of vegetation that did not exist prior to the project.

Resource Implications for Socioeconomic Activities

Table 7 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District. Resource implications for these four groups are discussed in sequence below.

Corps' Operations

Table 7 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus about 225 people derive jobs and income directly from Corps' operations. The annual direct cost to taxpayers for lock and dam operations is $2,601,000 (FY 1970) and for dredging operations is $1,200,000. Specific environmental costs of the stable water levels in the pools and the nine-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams and a reduction in fish and waterfowl habitat due to improper dredge spoil placement.

Table 7.

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps' Operations	Lock and dam (L/D) operation	1. L/D employments. 2. Stable water levels.	1. Cost of L/D operation. 2. Sedimentation behind dams and wing
	Dredging Operations	1. Dredging employment. 2. 9-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat due to improper dredge spoil placement.
Industrial	Barge Operation	1. Barge Employment. 2. Low cost water transportation. 3. Energy saving compared to alternate transportation modes	1. Increased river turbidity. 2. River pollution from oil and gasoline from barges.
	Commercial Dock Operation	1. Dock employment. 2. Attraction of barge transportation oriented firms that provide local employment	1. Increased river pollution from industrial [illegible]vities along shore.
	Commercial Fishing and Trapping	1. Increased employment of fishermen and trappers. 2. Increased number of fish and pelts available for consumers.	
Recreational	Boating Activity	1. Increased recreational opportunities for boaters.	
	Operation of Recreational Facilities	1. Increased employment and business opportunities for facilities serving recreational users of the river (boaters, sport fishermen and hunters, etc.)	

Table 7 continued

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (Cont.)	Sport Fishing	1 Initially increased habitat for fish	3 Increased sedimentation in fish habitat 2 Decreased fish habitat from improper dredge spoil placement
	Sport Hunting	1 Initially increase habitat for waterfowl	3 Decreased waterfowl habitat from improper dredge spoil placement
	Sightseeing, camping, picnicking, swimming, water skiing	1 Improved opportunities for miscellaneous recreational activities	
Cultural	Archaeological Sites		3 Loss of selected sites due to L/D construction and rising water
	Historical Sites		3 Loss of selected sites due to L/D construction and rising water
	Contemporary Sites		3 Loss of selected sites due to L/D construction and rising water

Industrial Activities

As summarized in Table 7 , the major direct impacts of Corps' operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 7 notes that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation with respect to

1. Energy usage
2. Air Pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition savings in transportation costs due to barge movements are discussed.

Barge Transportation and Energy Usage. Effective energy utilization is particularly important due to the present (and probably continuing) energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U.S. energy budget for motive power alone. This usage has been increasing at an average annual rate of about 4 percent per year.

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of freight transportation (Mooz, 1973):

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of

transportation and the size of inventories considered to be suitable. If the energy costs rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-buld commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines. Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects (U.S.P.H.S., 1968):

	Emission Factor	
Type of Emission	Pounds/1,000 gallons diesel fuel	Pounds/1,000 gallons gasoline
Aldehydes (HCHO)	10	4
Carbon monoxide	60	2300
Hydorcarbons(0)	136	200
Oxides of Nitrogen (NO_2)	222	113
Oxides of Sulfur (SO_2)	40	9
Organic Acids (acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these

characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 7 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 7 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U. S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, et al., 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks virtually all river users are not away from home overnight and are omitted form such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value at $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

[a]Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.

[b]Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds

available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No attempt has been made in the present study to place dollar values on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit.

SECTION 6 - SOCIOECONOMIC REFERENCES

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7. IRREVERSIBLE COMMITMENTS

A simple inventory of commitments and their implications in Navigation Pool No. 8 can probably best describe the situation.

1. Loss of natural resources

   A. Loss of wetlands due to inundation of the floodplains in the pool areas.

2. The commitment of labor, materials and energy for the construction of the lock and dam and related facilities.

3. The commitment of dollars for the purchase of the land now inundated in Navigation Pool No. 8.

4. The loss of wildlife and fish habitats at the following points in Pool No. 8 due to the deposition of unstabilized dredge spoils: (Table A20).

A.	Mile 687-689 (Lower Crosby Slough)	51000 cu. yds/yr
B.	Mile 689-691 (Brownsville & Crosby) Slough	39000 cu. yds/yr
C.	Mile 691-693 (Mormon Slough)	13820 cu. yds/yr
D.	Mile 693-695 (Coney Island)	12977 cu. yds/yr
E.	Mile 699-710 (Minnesota Island)	42000 cu. yds/yr

5. The energy and dollars required to carry out the above mentioned maintenance dredging as well as the remainder of the dredging at other sites in the pool.

8. RECOMMENDATIONS

The significant changes that have occurred in Navigation Pool No. 8 are those that are associated with the transformation of a river habitat to one that approximates a lake. The recommendations cited in this document are associated with those phases of the project that have available options.

The general recommendations refer to operational policies of the Corps of Engineers, whereas the specific recommendations are related to identified problem areas within Navigation Pool No. 8.

General Recommendations

1. That a review of all dredge spoil sites be made to determine whether the sites can adequately handle the amount of dredge spoil proposed for the future.

2. That the Corps of Engineers investigate and develop a market for dredge spoil materials, so that they can be used for beneficial purposes outside of the river basin.

3. That equipment (shorepipe, floating pipe, and booster pumps) be purchased to move the dredge spoil farther from the floodplain.

4. That a demonstration project be initiated to determine whether the channel can be maintained at a lesser depth, to minimize the amount of "over-dredging" in areas where materials are dredged every year. That the Corps of Engineers seek authorization to construct containment structures to restrict movement of the spoil material back into the channel in certain areas.

5. That the Corps of Engineers initiate revegetation procedures to aid in the stabilization of the spoil material.

6. That in no places should dredge spoil be placed in a linear fashion along the perimeter of the channel and result in effective channelization.

7. That the Corps of Engineers initiate a study to determine the feasibility of controlling water levels in the pool, for the management of rooted vegetation species as well as fish and wildlife. The establishment and maintenance of root vegetation species is closely related to water depth. Discouragement and encouragement of growth of these organisms could probably be managed by controlling water levels.

The examination of dredge sites in Navigation Pool No. 8 indicate that there are areas that are particularly sensitive to sedimentation and are in danger of being lost as a valuable recreational resource. They are:

1. Coney Island
2. Mormon Slough
3. Crosby Slough

We recommend the following with regard to these areas:

1. That dredge spoil in the area of Coney Island be removed from the floodplain or contained. Coney Island is unstable at the present time. The previously dredged material has eroded into the channel on the Minnesota side of the site. Deposition of more spoil material on the island will result in the complete filling of that slough behind the island.

2. That no dredge spoil be placed at or near Mormon Slough such that it will enter the slough or the channel immediately behind the spoil site. Mormon Slough represents the only major water supply channel for the middle and lower Goose Island area.

3. That dredge spoil material in the area of Crosby Slough be removed from the floodplain or revegetated. Unstabilized sediments in this area tend to be displaced downstream into the upper end of the open pool area, causing this area to become shallower and consequently less valuable as a fish and wildlife habitat. The loss of most of the benthic macroinvertebrates in this area during the summer of 1973 demonstrated this.

The concept of concentrating spoil into pre-defined areas, and the subsequent development of these areas for recreational use may be feasible, provided that the following criteria are met:

1. That the site(s) be located where the material, if eroded, will not encroach on water supply channels to backwater areas.

2. That the site(s) not destroy any existing prime habitats.

3. That after establishment of these sites, proper management procedures be practiced to insure their stability and longevity.

The accumulation of sediment has resulted in the loss of species diversity. The replacement of productive sediments with unstable unproductive sediments and the increase of the rate of eutrophication in the backwater areas. In addition to this, dredging in the channel and the subsequent deposition of the spoil material along the banks of the channel results in the increase in hydraulic efficiency but also

to the loss of water supplies into the backwater areas. This is the first of many steps toward the loss of the backwater areas as usable habitats for fish and wildlife. Maintenance of adequate, silt-free water into these areas is necessary for their preservation.

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APPENDIX

APPENDIX A TABLES

Table A1. Average tree composition of southern Wisconsin upland xeric forest, importance value, and percent constancy (from Curtis, 1971).

SPECIES	Av. I. V.	Constancy
Quercus alba	80.3	88%
Q. borealis	21.7	54
Q. velutina	98.3	92
Tilia americana	0.8	10
Prunus serotina	23.2	86
Quercus macrocarpa	25.6	64
Acer saccharum	0.2	2
Ulmus rubra	3.8	20
Carya ovata	8.2	53
Fraxinus americana	1.2	10
Quercus ellipsoidalis	10.6	10
Populus grandidentata	1.3	18
Ostry a virginiana	0.6	10
Ulmus americana	3.7	24
Acer rubrum	1.5	14
Carya cordiformis	2.1	16
Juglans nigra	2.7	34
J. cinerea	0.2	6
Quercus muhlenbergii	2.6	2
Acer negundo	1.8	10
Populus tremuloides	18.	16
Betula papyrifera	0.4	8
Fraxinus pennsylvanica	0.6	2
Fagus grandifolia	....	..
Ulmus thomasi	....	..
Celtis occidentalis	0.2	2
Quercus bicolor	....	..
Fraxinus nigra	....	..
Betula lutea	....	..

Table A2. Prevalent upland groundlayer species, southern Wisconsin, percent presence, and average frequency (Curtis, 1971).

SPECIES	Pres.	Av. Freq.
Adiantum pedantum	81%	6.9%
Agrimonia gryposepala	43	1.0
Amphicarpa bracteata	94	21.6
Anemone quinquefolia	65	6.2
A. virginiana	41	0.8
Apocynum androsaemifolium	52	2.6
Aralia nudicaulis	76	11.9
A. racemosa	61	1.2
Ariseama triphyllum	81	17.2
Aster saggitfolius	54	3.9
A. shortii	61	4.7
Athyrium filix-femina	74	7.6
Botrychium virginianum	83	6.3
Brachyelytrum erectum	67	7.2
Carex pensylvanica	78	14.4
Caulophyllum thalictroides	65	3.3
Celastrus scandens	67	7.8
Cornus alternifolia	48	1.6
C. racemosa	70	11.5
C. rugosa	43	2.2
Corylus americana	82	10.7
Cryptoteania canadensis	59	5.4
Desmodium glutinosum	93	7.9
Dioscorea villosa	57	2.7
Fragaria virginiana	57	4.1
Galium aparine	50	10.1
G. concinnum	93	26.0
G. triflorum	50	4.3
Geranium maculatum	100	35.8
Geum canadense	50	6.4
Helianthus strumosus	63	6.7
Hydrophyllum virginanum	44	5.5
Hystrix patula	67	2.6
Lactuca spicata	52	2.0
Lonicera prolifera	57	3.6
Osmorhiza claytoniana	46	3.9
Parietaria pensylvanica	43	4.6

Table A3. Average tree composition, southern Wisconsin wet lowland forest, importance value, and percent constancy (Curtis, 1971).

SPECIES	Av. I. V.	Constancy
Acer saccharinium	81.6	81.5%
Ulmus americana	26.5	66.7
Salix nigra	64.0	70.3
Populus deltoides	54.5	70.4
Fraxinus pennsylvanica	8.2	51.9
Betula nigra	24.4	51.8
Quercus bicolor	15.2	29.6
Tilia americana	1.6	11.1
Fraxinus nigra	2.9	18.5
Quercus borealis	0.3	3.7
Fraxinus americana	0.8	11.1
Quercus macrocarpa	5.8	3.7
Ulmus rubra	0.8	3.7
Carya ovata	0.2	3.7
Quercus alba	0.2	3.7
Q. valutina	3.6	3.7
Acer negundo	3.0	22.2
Carya cordiformis	0.4	7.4
Prunus serotina	0.7	3.7
Populus tremuloides	0.2	3.7
Salix amygdaloides	0.2	3.7

Table A4. Prevalent lowland groundlayer species, southern Wisconsin, percent, presence, and average frequency (Curtis, 1971).

SPECIES	Pres.	Av. Freq.
Amphicarpa bracteata	34%	10.1%
Arenaria lateriflora	34	9.0
Arisaema triphyllum	66	17.2
A. dracontium	44	2.5
Aster lateriflorus	41	12.5
Athyrium filix-femena	39	3.8
Boehmeria cylindrica	47	7.6
Circaea quadrisulcata	34	8.8
Cryptotaenia canadensis	45	12.9
Cuscuta gronovii	31	3.3
Dioscorea villosa	31	3.3
Elymus virginicus	39	9.1
Galium triflorum	44	6.4
Geum canadense	61	11.5
Glyceria striata	41	6.7
Impatiens biflora	67	21.4
Laportea canadensis	77	39.7
Leersia virginica	36	11.8
Lycopus uniflorus	36	5.7
Menispermum canadense	34	4.8
Onoclea sensibilis	56	6.9
Osmorhiza claytoni	33	6.6
Parthenocissus vitacea	80	23.0
Polygonatum pubescens	33	6.2
Ranunculus abortivus	47	5.0
Rhus radicans	59	6.7
Ribes americanum	48	6.8
Sambucus canadensis	42	3.2
Sanicula gregaria	36	13.1
Smilacina stellata	34	5.5
Smilax ecirrhata	41	4.7
S. herbacea	41	2.0
Solanum dulcamara	39	4.2
Solidago gigantea	34	6.3
Steironema ciliatum	57	10.2
Viola cucullata	63	16.3
V. pubescens	36	11.2
Vitis riparia	58	3.4
Zanthoxylum americanum	36	3.9

Table A5. Prevalent species of emergent aquatic communities, southern Wisconsin, (Curtis, 1971).

SPECIES	Pres
Eleocharis acicularis	38%
Iris shrevei	29
Phragmites communis	38
Pontideria cordata	51
Sagittaria latifolia	62
Scirpus acutus	73
S. americanus	42
S. valisus	49
Sparganium eurycarpum	51
Typha latifolia	71
Zizania aquatica	53

Table A6. Prevalent species of submerged aquatic communities, southern Wisconsin, (Curtis, 1971).

SPECIES	Pres
Anarchis canadensis	42%
Ceratophyllum demersun	32
Eleocharis acicularis	26
Najas flexilis	68
Potamogeton gramineus	35
P. zosteriformis	28
Vallisneria americana	39

Other species with presence over 10%	
Bidens beckii	11%
Myriophyllum exalbescens	10
Potamogeton amplifolius	19
P. foliosum	11
P. friesii	16
P. illinoiensis	25
P. natans	11
P. pectinatus	26
Sagittaria graminea	10

Table A7. A checklist of algae collected from Navigation Pool No. 8, upper Mississippi River, 1970-1971.

CHLOROPHYTA

Class Chlorophyceae
Order Volvocales
Family Volvacaceae
Eudorina elegans Ehrenberg
Gonium pectorale Mueller
Pandorina morum (Muell.) Bory
Platydorina caudatum Kofoid
Volvox aureus Ehrenberg

Order Tetrasporales
Family Coccomyxaceae
Elakatothrix gelatinosa Wille
Family Palmellaceae
Sphaerocystis schroeteri Chodat

Order Ulotrichales
Family Ulotrichaceae
Ulothrix cylindricum Prescott
Ulothrix zonata (Weber & Mohr) Kuetzing
Family Chaetophoraceae
Draparnaldia sp.

Order Cladophorales
Family Cladophoraceae
Cladophora fracta (Dillw.) Wille

Order Chlorococcales
Family Chloroccaceae
Acanthosphaera zachariasi Lemmermann
Golenkinia radiata (Chod.) Wille
Family Characiaceae
Characium ambiguum Hermann
Family Hydrodictyaceae
Hydrodictyon reticulatum (L.) Lagerheim
Pediastrum boryanum (Turp.) Meneghini
Pediastrum boryanum var. undulatum Wille
Pediastrum duplex Meyen
Pediastrum simplex (Meyen) Lemmermann
Family Coelastraceae
Coelastrum microporum Maegeli

Table A7 continued

Family Oocystaceae
Ankistrodesmus falcatus (Corda) Ralfs
Cerasterias stuarastroides West & West
Chlorella sp.
Chlorella vulgaris Beyerinck
Dictyosphaerium pulchellum Wood
Echinosphaerella limnetica G. M. Smith
Polyedriopsis spinulosa Schmidle
Quadrigula chodatii (Tan.-Ful.) G. M. Smith
Seleastrum gracile Reinsch
Treubaria setiherum (Archer) G. M. Smith
Family Scenedesmaceae
Actinastrum hantzschii Lagerheim
Actinastrum hantzschii var. *fluviatile* Schroeder
Crucigenia tetrapedia (Kirch.) West & West
Errerella bormhemiensis Conrad
Micractinium pusillum var. *elegans* G. M. Smith
Scenedesmus quadricauda (Turp.) de Brebisson
Scenedesmus quadricauda var. *maximus* West & West
Scenedesmus quadricauda var. *Westii* G. M. Smith

Order Zygnematales
Family Zygnemataceae
Mougeotia sp.
Spirogyra sp.
Family Desmidiaceae
Closterium sp.
Staurastrum sp.

EUGLENOPHYTA
Order Euglenales
Family Euglenaceae
Euglena sp.
Phacus sp.

PYRRHOPHYTA
Class Dinophyceae
Order Dinokontea
Family Ceratiaceae
Ceratium hirundinella (O. F. Muell.) Dujardin

Table A7 continued

Order Dinoccales
Family Dinococcaceae
Cystodinium cormifax (Schill.) Klebs

CHRYSOPHYTA
Class Chrysophyceae
Order Chrysomonadales
Family Mallomonadaceae
Chrysosphaerella longispina Lauterb.
Mallomonas alpina Pascher & Ruttner
Family Synuraceae
Synura uvella Ehrenberg
Family Ochromaonadaceae
Dinobryon sp.

Class Bacillariophyceae
Order Centrales
Family Coscinodiscaceae
Coccinodiscus sp.
Cyclotella sp.
Stephanodiscus sp.
Family Rhizosoleniaceae
Rhizosolenia sp.

Order Pennales
Family Tabellariaceae
Tabellaria sp.
Family Fragilariaceae
Asterionella sp.
Fragilaria sp.
Family Naviculaceae
Navicula sp.

CYANOPHYTA
Class Myxophyceae
Order Chroococcales
Family Chroococcaceae
Aphanocapsa spp.
Chroococcus sp.
Coelosphaerium spp.
Gloeocapsa spp.
Gomphosphaeria spp.
Marssoniella elegans Lemm.
Merismopedia glauca (Ehrenb.) Naegeli
Microcystis spp.

Table A7 continued

Order Hormogonales
Family Oscillatoriaceae
Oscillatoria spp.
Spirulina laxa G. M. Smith
Family Nostocaceae
Anabaena spp.
Aphanizomenon flos-aquae (L.) Ralfs
Nostoc spp.
Family Rivulariaceae
Rivularia haematites (D. C.) C. A. Agardh

Table A8. Checklist of mammals and waterfowl inhabiting the upper Mississippi River, Navigation Pool No. 8, 1970.

Moose	*Alces alces*
Whitetail Deer	*Odocoileus virginianus*
Antelope	*Antilocapra americana*
Black Bear	*Ursus americanus*
Snowshoe Hare	*Lepus americanus*
Whitetail Jackrabbit	*Lepus townsendi*
Swamp Rabbit	*Sylvilagus aquaticus*
E. Cottontail Rabbit	*Sylvilagus floridanus*
E. Fox Squirrel	*Sciurus niger*
E. Gray Squirrel	*Sciurus carolinensis*
Red Fox	*Vulpes fulva*
Gray Fox	*Urocyon cinereoargenteus*
Racoon	*Procyon lotor*
Opossum	*Didelphis marsupialis*
Mink	*Mustela vison*
River Otter	*Lutra canadensis*
Least Weasel	*Mustela rixosa*
Shorttail Weasel	*Mustela erminea*
Longtail Weasel	*Mustela frenata*
Striped Skunk	*Mephitis mephitis*
Spotted Skunk	*Spilogale putorius*
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethica*
Ruffed Goose	*Bonasa umbellus*
Sharp-tailed Grouse	*Pedioecetes phasianellus*
Bobwhite Quail	*Colinus virginianus*
Hungarian Partridges	*Perdix perdix*
Ring-necked Pheasant	*Phasianus colchicus*
Wild Turkey	*Meleagris gallopavo*
Mourning Doves	*Zeniadura macroura*

Table A3 continued

Rock Dove	*Columba livia*
Woodcock	*Philohela minor*
Common Snipe	*Capella gallinago*
King Rail	*Rallus elegans*
Virginia Rail	*Rallus limicola*
Sora Rail	*Porzana carolina*
Canada Goose	*Branta canadensis*
Snow Goose	*Chen hyperborea*
Blue Goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Black Duck	*Anas rubripes*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
Green-winged Teal	*Anas carolinensis*
Blue-winged Teal	*Anas discors*
American Widgeon	*Mareca americana*
Shoveler	*Spatula clypeata*
Wood Duck	*Aix sponsa*
Redhead	*Aythya americana*
Canvasback	*Aythya valisineria*
Lesser Scaup	*Aythya affinis*
Ring-necked Duck	*Aythya collaris*
Bufflehead	*Bucephala albeola*
Ruddy Duck	*Oxyura jamaicensis*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*Mergus serrator*
Hooded Merganser	*Lophodytes cucullatus*
Coot	*Fulica americana*
Common Gallinule	*Gallinula chloropus*

Supplement for Tables [illegible]

Treatment	Subdivisions (Stations)	F-Table Coordinates	99%	95%
AA	([illegible])([illegible])([illegible])([illegible])	3,9	6.99	3.86
BB	([illegible])([illegible])([illegible])	2,37	5.06	3.09
CC	None	....	....	....
DD	([illegible])([illegible])([illegible])	2,30	5.39	3.39
SS	(1-40, time series)	[illegible]	[illegible]	[illegible]

Computer Treatments ([illegible] Create Program for [illegible] ANOVA Analysis of Variance Program)**

1. Temperature
2. Depth
3. Turbidity
4. Conductivity
5. Nitrate
6. Nitrite
7. Phosphate
8. Dissolved Oxygen

**Means, F-distribution value and significance levels are listed in the numerical order shown above. Only the 95% and the 99% limits were listed. Any value below this was interpreted as not significant.

Table A9. Subgroup sample mean values, F-distribution value and level of significance for all parameters determined on Transect AA, Navigation Pool No. 8, Summer, 1973.

PARAMETER	TBAR 1 (1-4)	TBAR 2 (5-6)	TBAR 3 (7-9)	TBAR 4 (10-13)	F-value (3,9)	Sig.
1. Temp	25.000	26.000	24.000	23.000	62.223	99%
2. Depth	4.875	0.700	5.066	4.625	0.450	none
3. Turb.	15.750	45.000	12.000	32.000	13.393	99%
4. Cond.	28.750	25.000	33.666	38.750	331.901	99%
5. Nitrate	0.087	0.000	0.056	0.000	0.126	none
6. Nitrite	0.010	0.020	0.011	0.000	1.811	none
7. Phosphate	0.222	0.410	0.333	0.222	2.134	none
8. D. O.	13.649	6.600	8.899	12.299	78.771	99%

** See supplement on preceding page.

Table A10. Subgroup sample mean values, F-distribution value and level of significance for all parameters determined on Transect BB, Navigation Pool No. 8, Summer, 1973.

PARAMETER	TBAR 1 (1-6)	TBAR 2 (7-37)	TBAR 3 (38-52)	F-value 2,37	Sig.
1. Temp	26.333	25.421	23.666	22.754	99%
2. Depth	2.116	1.249	0.906	3.252	95%
3. Turb.	70.000	69.993	37.266	8.049	99%
4. Cond.	29.500	28.781	32.133	5.904	99%
5. Nitrate	0.030	0.088	0.000	0.057	none
6. Nitrite	0.003	0.008	0.003	0.520	none
7. Phosphate	0.086	0.492	0.479	9.896	99%
8. D. O.	11.249	7.453	5.859	6.636	99%

** See supplement on preceding page.

Table A11 Subgroup sample mean values, F-distribution value and level of significance for all parameters determined on Transect DD, Navigation Pool No. 8, Summer, 1973.

PARAMETER	YBAR 1 [illegible]	YBAR 2 (19-21)	YBAR 3 (22-31)	F-value 2,28	Sig.
1 Temp	[illegible]	26.333	24.400	13.167	99%
2 Depth	[illegible]	[illegible]	1.529	7.966	99%
3 Turb	[illegible]	63.333	51.000	5.356	95%
4 Sand	[illegible]	28.333	30.400	1.150	none
5 Nitrate	[illegible]	0.000	0.000	0.000	none
6 Nitrite	[illegible]	0.001	0.005	0.530	none
7 Phosphate	[illegible]	[illegible]	0.384	11.867	99%
8 [illegible]	[illegible]	[illegible]	5.189	6.895	99%

**See supplement on preceding page

Table A12. Biomass of benthic organisms and rooted vegetation Transect B, Stations 1-52, Navigation Pool No. 8, 1973

STATION	TOTAL BIOMASS BENTHOS (g/m^2)	TOTAL BIOMASS ROOTED VEGETATION (g/m^2)	GRAND TOTAL (g/m^2)
1	1.771	NONE	1.771
2	0.000	NONE	0.000
3	1.307	NONE	1.307
4	4.213	NONE	4.213
5	1.468	NONE	1.468
6	0.121	NONE	0.121
7	0.222	NONE	0.222
8	0.913	NONE	0.913
9	21.530	NONE	21.530
10	9.763	NONE	9.763
11	0.923	NONE	0.923
12	6.083	NONE	6.083
13	6.500	1012.938	1019.438
14	0.060	NONE	0.060
15	14.883	NONE	14.883
16	31.208	418.406	449.614
17	37.676	44.166	81.842
18	67.668	570.265	637.933
19	19.312	510.265	529.686
20	2.360	NONE	2.360
21	4.764	NONE	4.764
22	52.254	199.134	251.388
23	49.010	NONE	49.010
24	34.403	NONE	34.403
25	20.075	802.703	822.778
26	8.526	NONE	8.526
27	2.486	NONE	2.486

(Table A12 continued...)

STATION	TOTAL BIOMASS BENTHOS (g/m^2)	TOTAL BIOMASS ROOTED VEGETATION (g/m^2)	GRAND TOTAL (g/m^2)
28	23.678	NONE	23.678
29	18.622	104.843	123.465
30	30.118	156.375	186.493
31	23.990	NONE	23.990
32	30.030	NONE	30.030
33	5.776	NONE	5.776
34	5.946	NONE	5.946
35	8.134	NONE	8.134
36	67.304	NONE	67.304
37	8.131	NONE	8.131
38	26.831	NONE	26.831
39	10.694	NONE	10.694
40	2.668	NONE	2.668
41	9.567	NONE	9.567
42	3.639	3007.017	3010.656
43	36.709	1318.695	1355.404
44	17.754	1603.076	1620.830
45	13.037	101.143	114.180
46	11.858	NONE	11.858
47	20.894	NONE	20.894
48	40.998	NONE	40.998
49	49.799	NONE	49.799
50	11.370	76.200	87.570
51	65.123	98.266	163.389
52	74.142	35.496	109.638

TABLE A13

Frequency of Trees in Alluvial forest encountered along Transect 8*

Alluvial forest-Trees	
Ulmus americana L.	.87
Acer saccharinum Marsh.	.80
Quercus bicolor Willd.	.73
Betula nigra L.	.60
Fraxinus pennsylvanica Marsh.	.60
Salix interior Rowlee	.27
Salix rigida Muhl.	.27
Carya cordiformis (Wang.) K. Koch	.13
Gleditsia triacanthos L.	.13
Populus deltoides Marsh.	.13
Tilia americana L.	.13
Ulmus rubra L.	.13
Zanthoxylem americanum Mill.	.13
Betula pumila L. var *glandulifera* Regel	.07
Quercus bicolor Willd. x *Q. macrocarpa* Michx.	.07
Quercus bicolor Willd. with *Q. macrocarpa* Michx. introgressions	.07
Quercus rubra L.	.07
Salix amygdaloides Anderss.	.07
Salix lucida Muhl.	.07
Salix pyrifolia Anderss.	.17

* The figures represent the frequency with which a given species was found on islands or land masses classified as alluvial forest. Only one specimen need have been collected or noted for that species to be counted. This table can not be used to indicate relative abundance at a given site.

TABLE A14

Frequency of shrubs found in alluvial forest encountered along Transect 8

Alluvial forest-shrubs	
Cornus obliqua Raf.	.47
Cephalthus occidentalis L.	.40
Cornus racemosa Lam.	.13
Sambucus canadenis L.	.07
Spiraea alba Du Roi	.07
Viburnam lentago L.	.07

TABLE A15

Frequency of vines in alluvial forests encountered along Transect 8.

Alluvial forest-Vines	
Menispermum canadense L.	.27
Smilax herbacea L.	.20
Vitis riparia Michx.	.20
Smilax hispida Muhl.	.13
Parthenocissus quinquefolia (L.) Planch.	.13
Cuscuta sp.	.07
Parthenocissus inserta (Kerner) k. Fritsch.	.07

TABLE A16

Frequency of herbs in alluvial forests encountered along Transect 8.

Phalaris arundinacea L.	.87
Onoclea sensibilis L.	.47
Toxirodendron rydbergii	.47
Arisaema dracontium (L.) Schott	.27
Boehmeria cylindrica (L.) S.W.	.20
Carex tribuloides Wahlenb. (?)	.20
Equisetum arvense L.	.20
Laportea canadensis (L.) Wedd.	.20
Pilea pumila (L.) Gray	.20
Ranunculus abortivus L.	.20
Ambrosia trifida L.	.13
Anemone canadensis L.	.13
Carex scoparia Schk.	.13
Achillea millefolium L.	.07
Carex intumescens Rudge	.07
Cucuta maculatum L.	.07
Circaea quadrisulata (Maxim.) Franch. & Sav.	.07
Cirsium vulgare (Savi.) Tenore	.07
Cryptotaenia canadensis (L.) D.C.	.07
Eleocharis obtusa (Willd.) Schultes.	.07
Galium obtusum Bigel	.07
Geum canadense Jacq.	.07
Impatiens biflora Walt.	.07
Impatiens pallida Nutt.	.07
Lysimachia nummularia L.	.07
Oxalis stricta L.	.07
Physalis heterophylla Nees.	.07
Poa pratensis L.	.07
Polygonum arifolium L.	.07
Polygonum sagittatum L.	.07
Polygonum virginanum L.	.07
Rumex verticillatus L.	.07
Smilacina stellata (L.) Desf.	.07
Smilax ecirrhata (Engelm.) S. Wats.	.07
Thalictrum dioicum L.	.07
Urtica dioica L.	.07
Viola cucullata Ait (?)	.07
Viola missouriensis Green	.07

TABLE A17

Frequency of emergent species encountered in marshes along Transect 8.

Herbs	
Sagittaria rigida Pursh.	.64
Sagittaria latifolia Willd.	.54
Phalaris arundinacea L.	.36
Sagittaria rigida forma _fluitans_	.36
Scirpus validus Vahl.	.27
Sagittaria engelmannia J.G Smith	.18
Sparganium eurycarpum Engelm.	.18
Scirpus fluvitilis (Torr.) Gray	.09

TABLE A18

Frequency of submergent species found along Transect 8.

Deep Water

Ceratophyllum demersum	1.0
Elodea canadensis Michx.	.93
Potamogeton crispus L.	.93
Potamogeton foliosus Raf.	.64
Potamogeton pectinatus L.	.57
Potamogeton zosteriformus Fern.	.57
Potamogeton nodosus Poir.	.50
Nymphaea tuberosa Paine.	.36
Heteranthera dubia (Jacq.) MacM	.21
Nelumbo pentapetala (Walt.) Fern.	.14
Vallisneria americana Michx.	.14
Myriophyllum exalbescens Fern.	.07
Ranunculus circinatus Sibth.	.07

TABLE A20. Maintenance dredging activity, Cu. yds /mile reach of river/year, 1936-1967, average/yr., total average/yr., Pool No. 8

YEAR	675-81	681-83	683-85	685-87	687-89	689-91	691-93	693-95	695-97	697-99	699-701	701-2	TOTAL
						MILE							
1936	44349			36173	137691	50440	167300	57551	68337	44806	23002	193794	819784
1937													-0-
1938										115165	221000	37500	373665
1939											184074		184074
1940												101610	2134975
1941											158120		158120
1943					105473	33878		63411			218090	121056	541658
1944						69890		79839	134572		30311	24949	339561
1945													209170
1946			70547		110649						61467	30222	272885
1947						125080		33270			21189		179539
1948										71412		64746	136158
1949				42187	104401								146588
1950				105715	92509		86873	23118		22299	151910		482424
1951						100877		46380			12990		160247
1952					105338		56536					27917	189791
1953											130400		130400
1954					111256	57442		54336					223034
1955				56409							24370		80979
1956					106852	131115							237967
1957											23611		23611
1958						34122							34122
1959						44155							44155
1960					78212		45332						123544
1961						64614							64614
1962					32374	137683		37148			25970		233175
1963			31875	100935	112639								245449
1964					36920								36920
1965					40677	146753							187430
1966						95069							95069
1967			109306		457023	154536	86237	78790			39100		924992
AVE/Yr.	1385	-0-	6616	10050	50998	38926	13821	12977	4205	8240	42012	18831	282549

Table A21. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 1, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	0.000
Annelida	
Hirudinea	0.796
Oligochaeta	0.000
Isopoda	0.291
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.010
Ephemeridae	0.000
Coleoptera	0.009
Trichoptera	0.014
Diptera	
Tendipedidae	0.063
Heleidae	0.000
others	0.021
Total	1.771

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

Table A22. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect 8 Station [illegible], Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hirudinea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Chironomidae	0.000
Heleidae	0.000
others	0.000
Total	0.000

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A23 Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect 6 Station 3, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	0.495
Annelida	
Hirudinea	0.000
Oligochaeta	0.666
Isopoda	0.002
Amphipoda	0.004
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.123
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.007
Heleidae	0.000
others	0.000
Total	1.297

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

Table A24. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 4, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hirudinea	0.000
Oligochaeta	3.969
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.001
Ephemeridae	0.131
Coleoptera	0.001
Trichoptera	0.000
Diptera	
Tendipedidae	0.068
Heleidae	0.039
others	0.004
Total	4.213

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

[illegible]
[illegible]
[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible]	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Total	[illegible]

[illegible]	[illegible]
[illegible]	

Table A26. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 6 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hirudinea	0.000
Oligochaeta	0.002
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Chironomidae	0.054
Heleidae	0.062
others	0.003
Total	0.121

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table 27. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 7 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.006
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.014
Ephemeridae	0.077
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.011
Heleidae	0.107
others	0.007
Total	0.222

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A28. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 8 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.002
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.579
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.150
Heleidae	0.021
others	0.161
Total	0.913

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A29. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 9 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	5.946
Annelida	
Hiruninea	0.198
Oligochaeta	0.917
Isopoda	0.038
Amphipoda	0.036
Insecta	
Ephemeroptera	
Baetidae	0.067
Ephemeridae	13.879
Coleoptera	0.016
Trichoptera	0.069
Diptera	
Tendipedidae	0.083
Heleidae	0.034
others	0.247
Total	21.530

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A30. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 10 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	3.451
Annelida	
Hiruninea	0.043
Oligochaeta	5.636
Isopoda	0.004
Amphipoda	0.207
Insecta	
Ephemeroptera	
Baetidae	0.044
Ephemeridae	0.295
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.051
Heleidae	0.017
others	0.015
Total	9.763

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A31. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 11, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.495
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.333
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendinedidae	0.066
Heleidae	0.029
others	0.000
Total	0.923

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A32. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 12 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hirudinea	0.000
Oligochaeta	0.014
Isopoda	0.002
Amphipoda	0.004
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	5.763
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.042
Heleidae	0.012
others	0.246
Total	6.083

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A33. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 13, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	4.459
Annelida	
Hirudinea	0.204
Oligochaeta	1.152
Isopoda	0.213
Amphipoda	0.212
Insecta	
Ephemeroptera	
Baetidae	0.138
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.039
Diptera	
Tendipedidae	0.079
Heleidae	0.002
others	0.002
Total	6.500

TAXON (Vegetation)	BIOMASS (g/m^2)
Sagittaria Latifolia, Willd.	1012.938

Table A34. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 14, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.002
Isopoda	0.002
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.010
Diptera	
Tendipedidae	0.048
Heleidae	0.005
others	0.000
Total	0.060

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

Table A35. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 15 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	10.406
Annelida	
Hirudinea	0.002
Oligochaeta	1.330
Isopoda	0.004
Amphipoda	0.029
Insecta	
Ephemeroptera	
Baetidae	0.037
Ephemeridae	0.689
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.035
Heleidae	0.005
others	2.085
Total	14.983

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

Table A36. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect 5 station 16, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	28.777
Annelida	
Hirudinea	0.039
Oligochaeta	0.036
Isopoda	0.303
Amphipoda	0.335
Insecta	
Ephemeroptera	
Baetidae	0.009
Ephemeridae	5.580
Coleoptera	0.001
Trichoptera	0.000
Diptera	
Tendipedidae	0.108
Heleidae	0.018
others	0.000
Total	31.708

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum. L.	15.076
Elodea canadensis. Michx	3.974
Sagittaria rigida	.548
Sagittaria rigida. Pursh.	357.838
Lemnaceae	40.978
	418.406

Table A37. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect 6 station 17, Navigation Pool [illegible] 8, 19[illegible]

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	9.910
Annelida	
Hirudinea	0.540
Oligochaeta	3.649
Isopoda	0.354
Amphipoda	11.733
Insecta	
Ephemeroptera	
Baetidae	0.212
Ephemeridae	10.706
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.167
Heleidae	0.000
others	0.405
Total	37.676

TAXON (Vegetation)	BIOMASS (g/m²)
Elodea canadensis. Michx	2.193
Ceratophyllum demersum. L.	41.937
Total	44.166

Table A38. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 18, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	50.545
Annelida	
Hirudinea	2.130
Oligochaeta	1.190
Isopoda	0.827
Amphipoda	1.819
Insecta	
Ephemeroptera	
Baetidae	0.018
Ephemeridae	10.594
Coleoptera	0.000
Trichoptera	0.034
Diptera	
Tendipedidae	0.511
Heleidae	0.000
others	0.000
Total	67.668

TAXON (Vegetation)	BIOMASS (g/m^2)
Sagittaria latifolia, Willd	503.522
Elodea Canadensis, Michx	66.743
Total	570.265

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Table [illegible] [illegible] of [illegible], and standing crop [illegible] of [illegible], [illegible] station 20, [illegible] [illegible]

Group [illegible]	[illegible]
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[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Total	[illegible]

Group [illegible]	[illegible]
NONE	

Table A41. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 21 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.973
Annelida	
Hirudinea	0.002
Oligochaeta	0.467
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.831
Coleoptera	0.096
Trichoptera	0.000
Diptera	
Tendipedidae	0.234
Heleidae	0.000
others	0.161
Total	4.764

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A42. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 22 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	3.468
Annelida	
Hiruninea	0.362
Oligochaeta	1.757
Isopoda	0.494
Amphipoda	0.927
Insecta	
Ephemeroptera	
Baetidae	0.029
Ephemeridae	44.553
Coleoptera	0.003
Trichoptera	0.000
Diptera	
Tendipedidae	0.307
Heleidae	0.022
others	0.322
Total	52.254

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum, L.	6.990
Elodea canadensis, Michx	96.072
Lemnaceae	7.812
Sagittaria latifolia, Willd.	88.260
Total	199.134

Table A43. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 23 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	33.696
Annelida	
Hiruninea	0.184
Oligochaeta	0.488
Isopoda	0.134
Amphipoda	1.379
Insecta	
Ephemeroptera	
Baetidae	0.045
Ephemeridae	12.582
Coleoptera	0.045
Trichoptera	0.115
Diptera	
Tendipedidae	0.341
Heleidae	0.001
others	0.000
Total	49.010

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A44. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 24, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	32.210
Annelida	
Hiruninea	0.177
Oligochaeta	0.151
Isopoda	0.237
Amphipoda	1.064
Insecta	
Ephemeroptera	
Baetidae	0.062
Ephemeridae	0.000
Coleoptera	0.003
Trichoptera	0.120
Diptera	
Tendipedidae	0.377
Heleidae	0.002
others	0.000
Total	34.403

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A45. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 25 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	10.901
Annelida	
Hiruninea	0.073
Oligochaeta	7.907
Isopoda	0.124
Amphipoda	0.007
Insecta	
Ephemeroptera	
Baetidae	0.007
Ephemeridae	0.472
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.584
Heleidae	0.000
others	0.000
Total	20.075

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum, L.	76.885
Elodea canadensis, Michx	19.461
Lemnaceae	18.228
Sagittaria latifolia, Willd	688.129
Total	802.703

Table A46. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 26, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	7.433
Annelida	
Hirudinea	0.059
Oligochaeta	0.314
Isopoda	0.137
Amphipoda	0.395
Insecta	
Ephemeroptera	
Baetidae	0.047
Ephemeridae	0.005
Coleoptera	0.003
Trichoptera	0.080
Diptera	
Tendipedidae	0.053
Heleidae	0.000
others	0.000
Total	8.526

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A47. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect 8 station 27 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	1.982
Annelida	
Hirudinea	0.000
Oligochaeta	0.000
Isopoda	0.019
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.260
Ephemeridae	0.162
Coleoptera	0.006
Trichoptera	0.000
Diptera	
Tendipedidae	0.055
Heleidae	0.002
others	0.000
Total	2.486

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A48. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 28 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	14.246
Annelida	
Hirudinea	0.039
Oligochaeta	0.161
Isopoda	0.038
Amphipoda	0.282
Insecta	
Ephemeroptera	
Baetidae	0.050
Ephemeridae	8.748
Coleoptera	0.010
Trichoptera	0.021
Diptera	
Tendipedidae	0.070
Heleidae	0.008
others	0.005
Total	23.678

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A49. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 29 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	8.919
Annelida	
Hiruninea	0.910
Oligochaeta	0.907
Isopoda	2.741
Amphipoda	1.939
Insecta	
Ephemeroptera	
Baetidae	0.071
Ephemeridae	2.704
Coleoptera	0.060
Trichoptera	0.307
Diptera	
Tendipedidae	0.052
Heleidae	0.007
others	0.005
Total	18.622

TAXON (Vegetation)	BIOMASS (g/m^2)
Nelumbo pentapetala, Fern.	104.843

Table A50. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 30 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	19.326
Annelida	
Hirudinea	0.308
Oligochaeta	2.228
Isopoda	0.450
Amphipoda	0.230
Insecta	
Ephemeroptera	
Baetidae	0.001
Ephemeridae	5.009
Coleoptera	0.011
Trichoptera	0.104
Diptera	
Tendipedidae	0.202
Heleidae	0.000
others	0.021
Total	30.118

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum, L.	18.639
Elodea canadensis, Michx	40.430
Nelumbo pentapetala, Fern.	89.768
Sagittaria rigida, Pursh	7.538
Total	156.375

Table A51. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 31, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	5.450
Annelida	
Hirudinea	0.172
Oligochaeta	0.126
Isopoda	0.186
Amphipoda	1.154
Insecta	
Ephemeroptera	
Baetidae	0.038
Ephemeridae	16.627
Coleoptera	0.109
Trichoptera	0.034
Diptera	
Tendipedidae	0.089
Heleidae	0.000
others	0.005
Total	23.990

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

Table A52. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect 8 station 32 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	20.317
Annelida	
Hiruninea	0.202
Oligochaeta	0.035
Isopoda	0.087
Amphipoda	0.029
Insecta	
Ephemeroptera	
Baetidae	0.086
Ephemeridae	9.003
Coleoptera	0.025
Trichoptera	0.000
Diptera	
Tendipedidae	0.081
Heleidae	0.004
others	0.161
Total	30.030

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

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Table A53. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 33 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	1.486
Annelida	
Hiruninea	0.000
Oligochaeta	0.120
Isopoda	0.002
Amphipoda	0.048
Insecta	
Ephemeroptera	
Baetidae	0.050
Ephemeridae	3.951
Coleoptera	0.001
Trichoptera	0.000
Diptera	
Tendipedidae	0.115
Heleidae	0.003
others	0.000
Total	5.776

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A54. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 34 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	5.450
Annelida	
Hiruninea	0.047
Oligochaeta	0.086
Isopoda	0.020
Amphipoda	0.019
Insecta	
Ephemeroptera	
Baetidae	0.065
Ephemeridae	0.034
Coleoptera	0.073
Trichoptera	0.045
Diptera	
Tendipedidae	0.107
Heleidae	0.000
others	0.000
Total	5.946

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A55. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 35 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.477
Annelida	
Hiruninea	0.164
Oligochaeta	1.285
Isopoda	0.530
Amphipoda	0.368
Insecta	
Ephemeroptera	
Baetidae	0.044
Ephemeridae	2.811
Coleoptera	0.012
Trichoptera	0.000
Diptera	
Tendipedidae	0.271
Heleidae	0.006
others	0.166
Total	8.134

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A56. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 36 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	61.694
Annelida	
Hiruninea	0.000
Oligochaeta	1.148
Isopoda	0.220
Amphipoda	0.476
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	3.598
Coleoptera	0.000
Trichoptera	0.016
Diptera	
Tendipedidae	0.152
Heleidae	0.000
others	0.000
Total	67.304

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A57. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 37 , Navigation Pool No. 8 , 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	6.442
Annelida	
Hiruninea	0.096
Oligochaeta	0.901
Isopoda	0.049
Amphipoda	0.053
Insecta	
Ephemeroptera	
Baetidae	0.004
Ephemeridae	0.272
Coleoptera	0.000
Trichoptera	0.034
Diptera	
Tendipedidae	0.280
Heleidae	0.000
others	0.000
Total	8.131

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A58. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 38, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	24.777
Annelida	
Hiruninea	0.062
Oligochaeta	0.677
Isopoda	0.087
Amphipoda	0.167
Insecta	
Ephemeroptera	
Baetidae	0.015
Ephemeridae	0.730
Coleoptera	0.029
Trichoptera	0.025
Diptera	
Tendipedidae	0.228
Heleidae	0.003
others	0.031
Total	26.831

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A59. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 39 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	8.919
Annelida	
Hiruninea	0.127
Oligochaeta	0.122
Isopoda	0.026
Amphipoda	0.027
Insecta	
Ephemeroptera	
Baetidae	0.140
Ephemeridae	1.143
Coleoptera	0.001
Trichoptera	0.005
Diptera	
Tendipedidae	0.074
Heleidae	0.000
others	0.010
Total	10.694

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A60. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 40 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.414
Annelida	
Hiruninea	0.000
Oligochaeta	0.103
Isopoda	0.000
Amphipoda	0.002
Insecta	
Ephemeroptera	
Baetidae	0.011
Ephemeridae	0.124
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.006
Heleidae	0.000
others	0.008
Total	2.668

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A61. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 41 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	4.955
Annelida	
Hiruninea	0.000
Oligochaeta	0.671
Isopoda	0.000
Amphipoda	0.014
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	3.510
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.401
Heleidae	0.000
others	0.016
Total	9.567

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A62. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 42, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	1.486
Annelida	
Hiruninea	0.352
Oligochaeta	0.768
Isopoda	0.067
Amphipoda	0.564
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.289
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.100
Heleidae	0.021
others	0.010
Total	3.639

TAXON (Vegetation)	BIOMASS (g/m^2)
Sagittaria latifolia, Willd.	3007.017

Table A63. Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 43 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	28.989
Annelida	
Hiruninea	0.206
Oligochaeta	0.645
Isopoda	0.271
Amphipoda	1.297
Insecta	
Ephemeroptera	
Baetidae	0.130
Ephemeridae	4.783
Coleoptera	0.003
Trichoptera	0.016
Diptera	
Tendipedidae	0.184
Heleidae	0.007
others	0.169
Total	36.709

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum, L.	9.045
Elodea canadensis, Michx	153.496
Potamogeton crispus, L.	1.233
Potamogeton foliosus, Raf.	.685
Sagittaria latifolia, Willd.	1154.236
Total	1318.695

Table A64. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 44 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	7.928
Annelida	
Hiruninea	0.356
Oligochaeta	2.760
Isopoda	1.728
Amphipoda	3.378
Insecta	
Ephemeroptera	
Baetidae	0.166
Ephemeridae	1.037
Coleoptera	0.046
Trichoptera	0.171
Diptera	
Tendipedidae	0.030
Heleidae	0.007
others	0.247
Total	17.754

TAXON (Vegetation)	BIOMASS (g/m^2)
Sagittaria latifolia, Willd.	1579.914
Lemnaceae	9.731
Elodea canadensis, Michx	5.893
Ceratophyllum demersum, L.	7.538
Total	1603.076

Table A65. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 45 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.063
Oligochaeta	1.392
Isopoda	0.176
Amphipoda	0.142
Insecta	
Ephemeroptera	
Baetidae	0.011
Ephemeridae	10.926
Coleoptera	0.018
Trichoptera	0.067
Diptera	
Tendipedidae	0.037
Heleidae	0.000
others	0.241
Total	13.037

TAXON (Vegetation)	BIOMASS (g/m^2)
<u>Potamogeton</u> <u>foliosus</u>, Raf.	6.853
<u>Ceratophyllum</u> <u>demersum</u>, L.	3.974
<u>Nelumbo</u> <u>pentapetala</u>, Fern.	90.316
Total	101.143

Table A66. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 46 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.743
Annelida	
Hiruninea	0.267
Oligochaeta	1.530
Isopoda	1.368
Amphipoda	2.158
Insecta	
Ephemeroptera	
Baetidae	0.047
Ephemeridae	4.287
Coleoptera	0.000
Trichoptera	0.032
Diptera	
Tendipedidae	1.331
Heleidae	0.056
others	0.039
Total	11.858

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A67. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 47 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	18.642
Annelida	
Hiruninea	0.020
Oligochaeta	0.740
Isopoda	0.009
Amphipoda	0.042
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	1.306
Coleoptera	0.000
Trichoptera	0.016
Diptera	
Tendipedidae	0.083
Heleidae	0.028
others	0.008
Total	20.894

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A68. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 48 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.973
Annelida	
Hiruninea	0.000
Oligochaeta	2.353
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	34.989
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.199
Heleidae	0.001
others	0.483
Total	40.998

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A69. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 49 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	44.846
Annelida	
Hiruninea	0.027
Oligochaeta	3.102
Isopoda	0.018
Amphipoda	0.136
Insecta	
Ephemeroptera	
Baetidae	0.022
Ephemeridae	0.871
Coleoptera	0.000
Trichoptera	0.068
Diptera	
Tendipedidae	0.410
Heleidae	0.219
others	0.080
Total	49.799

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A70. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 50 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	9.613
Annelida	
Hirudinea	0.011
Oligochaeta	0.351
Isopoda	0.000
Amphipoda	1.267
Insecta	
Ephemeroptera	
Baetidae	0.025
Ephemeridae	0.001
Coleoptera	0.000
Trichoptera	0.060
Diptera	
Tendipedidae	0.031
Heleidae	0.002
others	0.009
Total	11.370

TAXON (Vegetation)	BIOMASS (g/m^2)
Ceratophyllum demersum, L.	35.085
Potamogeton zosteriformis, Fern.	41.115
Total	76.200

Table A71. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 51, Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	60.208
Annelida	
Hiruninea	0.137
Oligochaeta	0.561
Isopoda	0.000
Amphipoda	2.274
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	1.365
Diptera	
Tendipedidae	0.440
Heleidae	0.138
others	0.000
Total	65.123

TAXON (Vegetation)	BIOMASS (g/m^2)
Elodea canadensis, Michx	1.371
Heteranthera dubia, MacM.	1.508
Myriophyllum exalbescens, Fern.	6.853
Potamogeton crispus, L.	13.705
Potamogeton foliosus, Raf.	.548
Vallisneria americana, Michx	74.281
Total	98.266

Table A72. Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 52 , Navigation Pool No. 8, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	38.724
Annelida	
Hiruninea	0.114
Oligochaeta	32.212
Isopoda	0.002
Amphipoda	0.250
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	1.273
Coleoptera	0.000
Trichoptera	1.497
Diptera	
Tendipedidae	0.036
Heleidae	0.034
others	0.000
Total	74.142

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton zosteriformis, Fern.	16.994
Vallisneria americana, Michx	18.502
Total	35.496

APPENDIX B: ARCHAEOLOGICAL BACKGROUND

Recent Studies

National Register of Historic Places

References

ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now, there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-sized petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scrapbooks of clippings on archeological matters made by Lewis; numerous account books, vouchers and other miscellany...

"A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry, the mounds alone that were actually surveyed reach a grand total of over thirteen thousand -- to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Iowa, Nebraska, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." (Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indianna, and Michigan -- in all, eighteen states.)

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts... he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill an incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

(IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN)

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between

> the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former. It was in a cultivated field, and had itself been plowed over for years; yet it had still a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N. ½ of SE. ¼ of Sec. 23, T. 28, R. 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.
>
> 7. MOUNDS AT PRESCOTT, WISCONSIN
>
> At the angle formed by the confluence of the St. Croix and Mississippi rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakanteebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sited, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archeological sites which lie in the study area. This idea was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river is large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Corps of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats by water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list of inventory

of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota, and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1880's and all the data is filed in the Archaeological Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have been excavated, most have not been rechecked. Consequently

there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river valleys in question, to determine if sites formerly recorded are still there and, if not, how they were destroyed -- particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

Classification of Sites.

Group I. These are sites definitely known to have been destroyed by Corps of Engineers activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by burrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger.

b. sites which were destroyed, such as the mound groups at Dresbach, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by some unrelated project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.*

The Effect of Corps of Engineers Activities on Archaeological Sites By Pool.

The following chart is a breakdown by pool of archaeological sites affected by the Corps of Engineers. The sites are listed using the groupings defined above.

Pool No.	Group #1* (destroyed)	Group #2 (not affected)	Group #3* (uncertain)
2	2	1	7
3	4	2	11
4	0	1	7
5	1	0	1
5 or 5A	2	0	3
6	0	0	1
7	0	0	7
8	0	0	6
St. Croix	0	0	5
Minnesota	0	2	25
	9	6	73

*For a detailed description of the sites destroyed by the Corps of Engineers projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

Conclusions. Although this report is rather inadequate to determine the real impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engineers impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indians that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

Jan E. Streiff
University of Minnesota
February 1973

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Appendix 1.

Description of Sites Destroyed by Corps of Engineers Activity.

1. 21 WA 1 Schilling Site located SE ¼ Sec 32 T 27N R 21W
   A mound and village site located on Grey Cloud Island, Washington County, Pool #2. Site has been destroyed by raised water level.
2. 21 DK 1 Sorg Site located NE ¼ NE ¼ Sec 23 T 115N R 18W
   A habitation site located on Spring Lake, Dakota County, Pool #2. The site is under water now.
3. 21 GD 75 SW ¼ SE ½ Sec 32 T 114N R 15W
   A group of 45 mounds located on Prairie Island, Goodhue County, Pool #3. Thirty-eight mounds are under water, 7 are still above water but are being eroded away by the river.
4. 21 GD 1 Nauer Site located NW ¼ Sec 9 T 113N 15W
   A mound and village group located on the southern tip of Prairie Island, Goodhue County, Pool #3. The mounds were destroyed with the construction of Lock and Dam #3.
5. 21 GD 57 Nauer Site located NW ¼ Sec 9 T 113N R 15W
   Part of Site 1, above, Pool #3. Part of the village and several mounds were destroyed with the construction of the recreational area known as "Commissary Point", a picnic ground.

6. Unnumbered LeSueur and Perrot French Trading Post

This site is listed as destroyed through "negative evidence". The site is recorded as being on Prairie Island, Goodhue County, Pool #3, and all attempts to locate the site have failed. It is thus assumed that because the post was on the water's edge that it is now under water.

7. Unnumbered, Unnamed Sec 34 T 109N R 9W

This was a mound and habitation site at the mouth of the Whitewater River, Wabasha County, Pool #5. The landowner pointed the site out to the State Archaeologist after it had been covered with water.

8. Unnumbered Location T 108N 7W

The site is a group of mounds on Prairie Island, Winona County. The site was covered by a Corps of Engineers levee. Pool #5 or 5A.

9. Unnumbered same location as above.

This site, although spared in the first levee construction, was buried with the addition of a later levee.

Appendix 2.

Location of Sites Potentially Vulnerable to Damage by Future Construction, Operations, and Maintenance Activities.

Houston County	HU 13	T104 R4	HU 8	T102 R4
	HU 14	T104 R4	HU 7	T101 R4
	HU 15	T104 R4	HU 5	T101 R4

T = township
R = range

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which are Now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. Listed in the latest (1972) edition of the National Register of Historic Places are the following sites adjacent to the Mississippi, Minnesota, and St. Croix Rivers in Minnesota. These sites have not been destroyed or damaged extensively by previous Corps of Engineers activity, but must be considered as possibly vulnerable in the future:

Fort Snelling - located near the confluence of the Minnesota and Mississippi Rivers in Hennepin and Dakota Counties. This was the State's first military post and, until 1849, the northwesternmost outpost in the nation. Restoration of the fort is continuing and live interpretation of the past is scheduled daily for visitors. Cantonment New Hope, the site of the makeshift encampment occupied by the soldiers who built Fort Snelling, and located on low ground near the east end of the present day Mendota Bridge has been located by archaeological excavation, but has not been opened to the public.

Mendota Historic District - located in Dakota County, across the Minnesota and Mississippi Rivers from Fort Snelling. Mendota

is the oldest permanent white settlement in Minnesota. The historic buildings are located on the bluffs.

St. Anthony Falls Historic District and Pillsbury "A" Mill - an area on the east and west banks of the Mississippi River at St. Anthony Falls including Nicollet Island. The St. Anthony Falls district was the origin of the city of Minneapolis. The Falls area was rich in Indian folklore, before it was first seen and described in 1680 by Father Hennepin. The falls, about 75 feet high and several hundred yards wide, were originally valued for their scenic beauty and the area became important as a tourist attraction. Later, the Falls provided power for lumbering and flour milling, and in 1882, became the location of the first hydroelectric plant in the Western Hemisphere. Construction of a concrete apron over the falls to halt their once-rapid erosion generally diminished their scenic beauty. The falls were bridged in the 1880's by a stone arch railroad bridge, still in constant use, which is said to resemble a Roman aqueduct. The lower lock and dam were completed in 1956 and the upper lock and dam in 1963 by the Corps of Engineers.

Structures and sites considered worthy of preservation in the area include: Ard Godfrey Cottage, Lady of Lourdes Church, Nicollet Island, the Third Avenue Bridge, Stone Arch Bridge, and the Pillsbury "A" Mill, built in 1881, then the largest

flour mill in the world, and still in operation today.

Bartron Site - located in Goodhue County on the southern portion of Prairie Island in the Mississippi River bottomlands. (¼ Sec 9, T 113N., R 15W). This is a relatively undisturbed (by farming) site containing possible evidence of house form, village arrangement, and artifacts from the major Mississippian culture (1000 A.D. to 1700 A.D.). The site is owned by NSP and has been excavated by Professor Eldon Johnson (State Archaeologist). It is known that Pierre Le Sueur spent the winter of 1696 there.

Prairie Island is part of Sioux Indian Reservation which as described by Roy W. Meyer in 1961 as "...the last portion of Goodhue County to be settled. Although often described as an island in the Mississippi, the area is actually a part of the right bank of that river, cut off from the upland by an arm of the Vermillion River which parallels the Mississippi from Hastings to the lower end of the island. Since the construction in 1938 of Lock and Dam Number 3 in the Mississippi and the diversion of the Vermillion, the "island" has become a peninsula, slightly more than two miles in width. Prairie Island is almost completely flat and only about sixteen feet above the average water level of the river; hence, it is partially covered with lakes and sloughs and is subject to flooding. The soil is rich in humus, but sandy, and in drought years crops which mature late are likely to dry up." Meyer writes that muskrat

trapping was suggested as a possible source of income when the dam then being built raised the water level and produced ponds and sloughs.

Information on Prairie Island should continue to be studied. Suggested sources: the N. S. P. study by Eldon Johnson, "An Economic Survey of the Prairie Island Indian Community" by Clyde G. Sherman in Minnesota (an unpublished study in the possession of the Minnesota Agency in Bemidji), as well as those listed in the bibliography.

St. Croix Boom Site - located three miles north of Stillwater on the St. Croix River in Washington County. From 1840 to 1914 this was the terminal point for the white pine lumber industry. Here millions of logs were sorted, measured, and rafted to downstream sawmills. The boom site died naturally as a result of the depletion of timber late in the 19th Century. There are no remains of the log boom, but the general setting is unimpaired.

Marine Mill Site - located in Washington County at Marine-on-St. Croix. It is the site of Minnesota's first commercial saw mill which was founded in 1839. At present only the ruins of the engine house and a marker specify the site.

Sites Designated as Historic and Worthy of Preservation, Not Yet Included in The National Register, in Minnesota Which are Adjacent to the Minnesota, Mississippi, and St. Croix Rivers

1) The historic Old Frontenac area which includes the site of the

French Fort Beauharnais (Goodhue County) located on Pointe au Sable along the Mississippi. The original fort was flooded its first year and was later rebuilt on higher ground. Burned and abandoned in 1737, it was rebuilt and finally abandoned again in 1756. Nothing remains of the fort. However, cannon balls and lead bullets were recovered from Lake Pepin in the 1890's.

2) Shakopee Historic District (Scott County) along the lower bluffs of the Minnesota River near Shakopee. The location of Chief Shakopee's village from the 1820's to 1852 as well as a concentration of prehistoric Indian mounds and a grist mill. Additional buildings of historical significance are being brought to the site.

3) Silverndale Site and Associated Mounds (Goodhue County) adjacent to the Red Wing Industrial Park.

WISCONSIN

Early Archaeology

Increase A. Lapham recorded the results of Wisconsin archaeological research which he began in 1836 in The Antiquities of Wisconsin, published in 1850. Although his work was extensive and continued until his death in 1875, it focused on areas other than the Mississippi River Valley. He described sites along the Mississippi River as far north as the LaCrosse River; then concluded: "Only an occasional mound was observed along the valley of the LaCrosse River; and it is believed that no works of any considerable extent exist above this point on the Mississippi." See Figure 1.

A review of the publications of Lapham, Robert Ritzenthaler, and Charles E. Brown reveal that Wisconsin archaeological and historic sites, especially burial mounds, were extensive. The number of mounds in Wisconsin were estimated to number 15,000. Sites occurred on and near the shores on nearly every stream and lake. In addition to burial mounds, "sites of native villages, camps and workshops, plots of corn hills and garden beds; enclosures; burial places and cemeteries; refuse heaps and pits; cave shelters; shrines; pictograph rocks; boulder mortars; sources of flint, quartz, quartzite and pipestone; lead diggings; copper mining pits; stone heaps and circles; cairns; and trails" are of interest to the Wisconsin archaeologist. Burial mounds, village sites, forts, and pictographs are found in the Mississippi River Valley. See Figure 2.

Recent Archaeology

An important discovery was made in 1945 by two Mississippi River fishermen who "saw some artifacts projecting from the bank which had been undercut by the action of the River." The "Osceola Site" in Grant County is located two miles south of Potosi on the Mississippi River bank (NW ¼ of Sec. 14 T.2, N. Range 3, W of 4th Principal Meridian). Excavation of the burial mound revealed copper implements, as well as projectile points and banner stones. The copper implements provide evidence of the presence of Indians belonging to the "Old Copper Culture" who probably arrived in the State about 3000 B. C.

The site had been damaged, however, by rising water. Ritzenthaler who described the site in 1946, stated:

> Up to 8 years ago this was the bank of the Grant River, but the installation of a dam at Dubuque raised the water and widened the Mississippi at this point ... Test pits revealed that the burial pit extended about 70 feet along the bank, and was about 20 feet wide at this time, but it must have been considerably wider originally judging from the amount of material washed into the river.

No mention was made about intended future disposition of the site. Ritzenthaler also mentioned that another site, Raisbeck, in Grant County had been excavated, but he did not give an exact location. Other mounds were located on the Mississippi River bluffs above Potosi and were mentioned in the 1927 edition of Scenic and Historic Wisconsin.

Dr. Freeman stated that an extensive survey of sites was conducted in Crawford County when the St. Feriole Island buildings were recommended for inclusion in the National Register of Historic Places. St. Feriole

Island was originally a prairie between the Mississippi River and the bluffs of Prairie du Chien. It contained many burial mounds which were not effigy shaped. An article in 1853 by Lapham stated that the mounds "are so near the river that their bases are often washed by floods." During the highest known flood -- 1826 -- only the mounds could be seen above the surface of the water. The first fort was built on an Indian mound, as were several French homes. Lapham stated that the mound was excavated but that no remains were found in it. He did note some remains of an "American fort taken by the British in the War of 1812." Lapham, in visiting the mounds in 1852, found them "almost entirely obliterated due to cultivation and the light sandy nature of the materials."

In Pepin County, Ritzenthaler reported the existence of an Indian village site, 2 miles east of Pepin, along a wide terrace to the Mississippi. Pepin is also mentioned as the site of French forts including St. Antoine, built in 1686, above the mouth of Bogus Creek. In Trempealeau County, Nicolls Mound, the Schwert Mounds, and the Trowbridge site have been excavated. Perrot State Park in Trempealeau contains Indian mounds and the site of a log fort erected by N. Perrot, a French explorer, in 1685-6. Indian mounds are also preserved in LaCrosse.

In an article published in 1950, "Wisconsin Petroglyphs and Pictographs", Ritzenthaler enumerated the existence of the following petrographs. He did not specify their exact location. Their condition had been unchecked since 1929. Exact location and current condition should be checked with the state archaeologist. In Vernon, LaCrosse, Crawford,

and Trempealeau Counties, sandstone and limestone cliffs and caves with petrographs were recorded. Larson Cave in Vernon County contained petroglyphs described as being in excellent condition in 1929, Samual's Cave, LaCrosse County, containing petroglyphs and pictographs was first investigated in 1879 -- and was still in excellent condition in 1929. Galesbluff, LaCrosse County, contained petroglyphs carved on soft limestone. Nearly all of the petroglyphs in Trempealeau County in the Trempealeau and Galesville rock shelters have been destroyed -- either by road builders, erosion, or tourists. Pictographs were described by L. H. Bunnell in 1897, "a short distance above Prairie du Chien." Ritzenthaler did not report their present condition.

Future Studies

Dr. Freeman mentioned specific sites which have been flooded are located on Lake Pepin, at Trempealeau, and at Wyalusing. In the limited time available, this author could not locate any current publication describing the extent or present condition of sites known to have existed in Wisconsin. The Wisconsin Archaeologist, if reviewed issue by issue, would reveal considerably more data on the above mentioned sites, as well as other, perhaps more important, sites. However, lack of time precluded that examination. An examination of that publication, a review of the files in the historical society, and on-site visits would be required before one could be assured of an accurate analysis of present conditions of the sites.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation.

The only Wisconsin archaeological or historic site bordering the Mississippi or St. Croix rivers listed in the Register is in Crawford County on St. Feriole Island in the Mississippi River, at Prairie du Chien.

Astor Fur Warehouse, Brisbois House, Dousman Hotel, Second Fort Crawford, Villa Louis

All of the above structures are remains of the early settlement of Prairie du Chien as an early fur trade, steamship, and railroad center. They were constructed between 1808 and 1864 and most are still under private ownership.

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APPENDIX C: METHODS OF DATA COLLECTION

APPENDIX C. Methods of Data Collection

Water samples were collected at the surface with a Kemmerer bottle (capacity = 2 liters). The water temperatures were recorded immediately. The samples collected for oxygen determinations were fixed on site with Winkler reagents. All samples were stored in a refrigerator until analyses were completed.

Conductivity measurements were made with a Type RC Conductivity Bridge (Industrial Instruments Inc., Cedar Grove, N.J.). All readings were later converted to a u mhos at 25C.

Turbidity was determined with a 110 volt Turbidimeter (Model 1860 Hach (Hach Chem. Corp., Ames, Iowa).

Dissolved oxygen determinations were made using the azide modification of the Winkler technique. Determinations were made spectrophotometrically with a Spectronic 20 (Bausch and Lomb), at 450 mu.

Orthophosphate, nitrate nitrogen, and nitrite nitrogen determinations were made using Hach reagents, with the quantitative determinations made on a Spectronic 20 spectrophotometer.

The benthos was sampled using either a Petersen dredge or an Eckman dredge, depending upon the depth and the consistency of the sediments. All samples were washed through a #30 brass screen, and were preserved in formalin for later analysis. The samples were transported to the laboratory where they were placed in a sugar solution (density = 1.16) and were floated prior to separation. All

were then resuspended in water for further visual separation techniques. The organisms were then replaced in formalin prior to identification.

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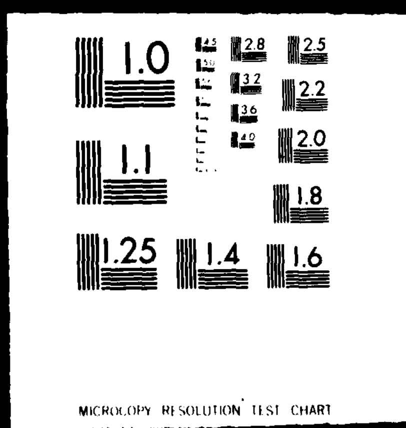

SUPPLEMENTARY

INFORMATION

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data available for similar communities at these latitudes and the vicinity of Navigation Pool No. 8, a probable list of species of the most important plants by occurrence, can be constructed (TableA5, A6). The percent occurrences shown are not for the Mississippi River basin, but are for similar community situations in western Wisconsin (Curtis, 1971).

Algae

Members of all classes and virtually all common orders of algae are found in the waters of Navigation Pool No. 8 (Table A7). Total population fluctuations in the Mississippi River are similar to those found in smaller streams and generally are similar to those found in lakes located at these latitudes. Whereas these data describe the present situation, data prior to the construction of the locks and dams are unavailable. However, there is no reason to conclude that the general patterns were not similar. The construction of locks and dams probably has had an indirect effect on phytoplankton populations, in that new habitats were created and are most likely conducive for the growth and proliferation of certain species. Nutrient cycles were most likely altered in some areas, and this presumably has had an effect on the responses of given species. This will be discussed in the impact section.

WILDLIFE

There are many wildlife species that provide hunting and trapping in the Upper Mississippi River basin (Table A8). Of the huntable

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